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. This result extends to the case of 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 affect the equilibrium price.

Keywords: E-commerce; Privacy concerns; Security concerns; Registration cost; Platform design; 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.\textsuperscript{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 at zero cost. 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. Moreover, 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 first. 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).

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 download and installation of the software, together with the setup of a user account.\textsuperscript{2} The same is true for many music streaming services. Other online stores offer certain features of their

\textsuperscript{1}Privacy 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 (private 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, Durbin and Salinger (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/.

\textsuperscript{2}In older versions of iTunes, setting up a user account required the provision of credit card or other valid payment information.
website only after registration and for users signed in to the website.\textsuperscript{3} Sometimes, detailed delivery information and services and total cost (including shipping fees and/or credit card fees) is only disclosed after signing in and at the very end of the checkout process.\textsuperscript{4}

The non-monetary registration cost caused by privacy and security concerns but also by the time necessary to set up an account may deter consumers from buying. In the baseline model in Section 2, we show that if the registration cost is sufficiently low, it is optimal for the firm to require registration ex ante. The main intuition for this result is similar to a sunk cost argument: If consumers are required to register ex ante, that is, before observing all relevant price and product information, the registration cost becomes irrelevant for a consumer’s purchasing decision. Hence, provided that consumers register, the firm 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 effect that ex ante registration makes (registered) consumers more willing to buy is orthogonal to the value that firms may derive from information about the consumers’ characteristics.

In Section 3, we analyze optimal platform design if there is price competition between firms. We assume that there is an incumbent firm which has a share $\beta \geq 0$ of loyal consumers who only consider buying at the incumbent 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. Suppose that the competing firm does not require ex ante registration and the consumers’ cost of registration is sufficiently low. Then, we show that for any $\beta > 0$ the incumbent firm has strictly higher profits when requiring ex ante registration, just as in the monopoly case.

In Section 4, we consider discount policies as a means to increase consumers’ incentives to register. 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 discounts 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 would be reinforced if the firm could target discounts

\textsuperscript{3}For 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.

\textsuperscript{4}In 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, Kang and Cheon 2006).
to consumers with high registration cost.\(^5\)

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 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.\(^6\) Moreover, 21% of internet users reported that they had an email or social networking account compromised or taken over and 11% had important information stolen (such as Social Security Number or credit card information).\(^7\)

Privacy and security concerns as a main difference between online shopping and traditional shopping have, so far, received only little attention in the literature. Shy and Stenbacka (2014) study privacy protection from a competition policy point of view.\(^8\) Bergemann and Bonatti (2013) analyze the demand for information and pricing decisions of data providers (who collect data, for instance, via third-party cookies). 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, Greiner and Ockenfels (2013). The registration cost, however, differs from 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.

More generally, our paper contributes to the literature on market structures and consumer behavior in online markets.\(^9\) A focus of this literature is on the impact of search and information acquisition technologies. There is a growing line of research that considers

\(^{5}\)See also Shaffer and Zhang (2002) on price competition with loyal consumers when, after setting and their prices, firms can target promotions to certain customers and induce consumers to switch to their brand.

\(^{6}\)Around 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, Rohm and Bahl (2004), around two third of respondents had decided not purchased at a website due to uncertainty about the use of personal information.

\(^{7}\)The 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, Dai and Zhang (2007) on the impact of perceived privacy and security risks on online shopping behavior and the survey by Anderson, Durbin and Salinger (2008) on costs and implications of identity theft.

\(^{8}\)For 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).

\(^{9}\)For surveys on internet markets and their characteristics see Bakos (2001) and Levin (2013).
how consumers search (Arbatskaya 2007; Armstrong, Vickers, and Zhou 2009; Armstrong and Zhou 2011; Branco, Sun, and Villas-Boas 2012) and the consequences of differences in search behavior for market design choices, pricing and competition (Baye and Morgan 2001; Hagiu and Jullien 2011; Bar-Isaac, Caruana, and Cuñat 2012).\textsuperscript{10} We add to this literature by considering privacy concerns and non-monetary registration costs as one of the key features of online shopping, and we focus on the consequences for platform design when firms can decide on the point in time at which the registration cost becomes relevant.

Our paper is also related to the literature on the revelation of price and product information in industrial competition. Anderson and Renault (2006) consider a structurally related 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.\textsuperscript{11} Moreover, a recent literature considers firms’ incentives 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 cost is low and price-elasticity of demand is high. In contrast to search costs, the registration costs considered in our paper can neither be reduced by advertising product information, nor be increased by using obfuscation strategies.\textsuperscript{12} Moreover, registration costs differ from search costs since the firm’s platform design can shift registration costs (but not search costs) to the point when consumers have already learned the price and all product characteristics. This choice of the timing of when the ‘registration cost’ has to be incurred is an important additional instrument for platform design in online markets, which is not available in traditional markets and for other types of transaction costs.

\textsuperscript{10}Despite the low search cost, many studies have found substantial price dispersion on the internet. See, for instance, Smith and Brynjolfsson (2001), Baye, Morgan, and Scholten (2004) and Baye, Morgan, and Scholten (2006) for a survey. See also Dinerstein, Einav, Levin, and Sundaresan (2014) for a measurement of mark-ups in online retail markets.

\textsuperscript{11}Further recent work on disclosure of product information includes Sun (2011), Anderson and Renault (2009, 2013) and Celik (2014).

\textsuperscript{12}Since shopping on the internet requires (in most cases) some payment and delivery information, buying inevitably involves a cost for consumers with privacy concerns, which cannot easily be reduced to zero. Moreover, consumers’ privacy and security concerns are at least partly independent of the counterparty, due to, for instance, the collection and misuse of data by third parties. There is, however, some discretion of firms over the amount of personal information required and, hence, potentially over the consumers’ registration cost, as we also discuss when concluding.
2 The logic of ex ante registration requirements

Model Suppose there is one firm (firm 1) 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 $\theta$. It is commonly known that the valuations are independent draws from a cumulative distribution function $F$ with support $[0, \infty)$. Unless otherwise stated, we assume that $F$ is twice differentiable and has a strictly monotone hazard rate:

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

Initially, consumers do not know their valuation; they can inspect the product and learn their $\theta$ prior to the purchase decision. In order to purchase the product, a buyer needs to register at the online shop. Registration comes at a non-monetary cost $k > 0$, which comprises the opportunity cost of the time needed to set up an account and the disutility due to privacy and security concerns.\(^\text{13}\)

The firm makes a platform choice consisting of a decision $r \in \{NR, R\}$ whether or not to require ex ante registration, and chooses a price $p$ (per unit of the product). If the firm requires ex ante registration ($r = R$), then, in order to learn his valuation and to observe the price, a consumer has to register and incur the cost $k$. If the firm does not require ex ante registration ($r = NR$), then consumers learn their valuation and the price without having to register; the cost $k$ is incurred if and only if a consumer decides to buy.

The timing of the game is as follows. At the beginning of stage 1, nature draws each consumer’s valuation $\theta$ independently from the distribution $F$. Then, the firm decides whether or not to require ex ante registration, 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 $r = R$, then, in stage 3, each buyer decides whether to register at cost $k > 0$. Registered consumers can observe the price $p$ and their valuation $\theta$ and decide if they want to buy one unit of the good; non-registered consumers cannot buy. If $r = NR$, all consumers observe $p$ and their $\theta$ and then decide whether or not to buy; conditional on buying, a consumer has to pay the registration cost $k > 0$.

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) $\theta - p - k$ if he buys, (ii) $-k$ if he registers but does not buy, and (iii) zero otherwise. The equilibrium concept is perfect Bayesian equilibrium.

\(^{13}\)Sections 2 and 3 assume $k$ to be identical for all consumers; see Section 4 for a discussion of heterogeneity in registration cost.
Before turning to the equilibrium of the game, we mention an alternative interpretation of the setup. Apart from unit demand for one product, the model also reflects markets such as music or video streaming services with a continuum of goods. In this case, $p$ can be interpreted as the price for a subscription and $\theta$ 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, $\theta$ 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 $\theta$, and buys if and only if $\theta \geq p + k$. 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. Hence, when choosing the price $p$, the firm’s price is the solution to

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

This yields an optimal price $p^{NR}$ which is implicitly defined by

$$p^{NR} = \frac{1 - F(p^{NR} + k)}{F'(p^{NR} + k)},$$

and a profit of

$$\pi^{NR} := (1 - F(p^{NR} + k)) p^{NR}.$$

**Ex ante registration** Suppose that firm 1 requires ex ante registration. Then, in stage 3, only registered consumers learn $p$ and their $\theta$. A (registered) consumer buys if and only if $\theta \geq p$.

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

$$\int_p^\infty (\theta - p) \, dF(\theta) \geq k.$$  

The buyers, however, do not know the price when deciding on registration. They therefore

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14 We assume the tie breaking rule that consumers buy whenever they are indifferent between buying and not buying.

15 Given the assumptions on $F$, there is a unique solution to the firm’s maximization problem.
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

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

This yields an optimal price $p^R$ given by

$$p^R = \frac{1 - F(p^R)}{F'(p^R)} \quad (3)$$

and a profit of

$$\pi^R := (1 - F(p^R)) \cdot p^R.$$ 

Anticipating this price, a buyer registers if and only if $k \leq \bar{k}$ where

$$\bar{k} := \int_{p^R}^{\infty} (\theta - p^R) \, dF(\theta). \quad (4)$$

Therefore, if $k \leq \bar{k}$, there is an equilibrium in which the firm chooses $p = p^R$ as in (3) and all buyers register and buy if and only if $\theta \geq p^R$.  

If instead $k > \bar{k}$, 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 $\mu \in (0, 1]$. Then, anticipating this registration decision, the firm will choose the price $p^R$. 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 $k > \bar{k}$: Anticipating the firm’s choice of the price, the expected surplus from registration is too low.

Before turning to the firm’s equilibrium platform decision, note that the assumption on $F$ implies the following ranking of prices:

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16 Again, due to the assumptions on $F$, there is a unique solution to the firm’s maximization problem given that all buyers register.

17 There is an additional set of equilibria in which the firm sets a (high) price at which (2) 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.

18 Since buyers don’t 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 choice of the price $p$ that is independent of $\mu$ (as long as $\mu > 0$).
Remark 1 Let $p^{NR}$ and $p^R$ be defined as in (1) and (3). Then,

$$p^{NR} < p^R < p^{NR} + k.$$ 

First, without ex ante registration, the firm’s optimal price $p^{NR}$ is lower than with ex ante registration. Second, the difference between $p^R$ and $p^{NR}$ is less than $k$ such that $p^{NR} + k$ is higher than the price with ex ante registration; this implies that there is less trade without ex ante registration than with ex ante registration (provided that the consumers indeed register).

Proposition 1 In equilibrium, a monopoly seller requires ex ante registration if and only if $k \leq \bar{k}$ (where $\bar{k}$ is given in (4)).

Proof. Suppose that $k \leq \bar{k}$. If the firm requires registration, it chooses the price $p^R$ as in (3). Since all consumers register, the firm’s expected profit is

$$\pi^R = (1 - F(p^R)) p^R$$

which is larger than $(1 - F(p)) p$ for all $p \neq p^R$ and, hence, larger than

$$(1 - F(p^{NR} + k)) (p^{NR} + k) > (1 - F(p^{NR} + k)) p^{NR} = \pi^{NR}.$$ 

If $k > \bar{k}$, the firm makes zero profits if it requires ex ante registration but strictly positive profits if it does not require ex ante registration. ■

The intuition for Proposition 1 is straightforward. If the consumers’ costs of registration are high, no one would be willing to register ex ante; therefore the firm does not require it. In contrast, if the cost is sufficiently small, consumers are willing to register ex ante. Then requiring ex ante registration is optimal for the firm. With ex ante registration, the registration costs $k$ are sunk when a consumer decides whether or not to purchase; ex ante registration detaches the registration costs from the purchase decision. Consequently, with ex ante registration, the firm sells to a larger share of consumers, and at a higher price. Each of these two effects makes the firm benefit from shifting the registration cost to the ex 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 (compare Remark 1). In addition, they pay $k$ independently of whether they buy. Both effects reduce consumer surplus compared to the case of no ex ante registration.
Proposition 1 does not hinge on the assumptions that $F$ is differentiable and has a monotone hazard rate. The results on the price ranking (Remark 1) and on consumer surplus depend, however, on the assumptions on the distribution function $F$. In Appendix A.1 we provide an example of a two-point distribution for which the price is lower, and consumer surplus is higher, with an ex ante registration requirement.

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. Defining welfare $W$ as the sum of the firm’s expected profits and the consumers’ expected utility, the welfare effect in case of $k \leq \bar{k}$ is given by

$$
\Delta W = W^R - W^{NR} = \int_{p^R}^{p^{NR}+k} \theta dF(\theta) - F(p^{NR}+k) k.
$$

First, if $p^R < p^{NR} + k$ as in Remark 1, there is more trade with ex ante registration requirement, which is welfare improving since, in equilibrium, there is inefficiently low trade.\(^{19}\) Second, however, with ex ante registration, the cost of registration is incurred independently of whether a consumer actually buys, which reduces welfare. If $F$ is a uniform distribution, for instance, then $\Delta W$ is negative; the negative effect of the cost of registration prevails and leads to higher welfare without an ex ante registration requirement. But, as mentioned already above, there are also examples for distributions $F$ for which welfare is higher with than without ex ante registration (see the example in Appendix A.1).

To conclude this section, we will briefly discuss the assumption that, in case of an ex ante registration requirement, price and valuation 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 $p = p^R$ in equilibrium. In other words, Proposition 1 establishes a “lower bound” for platform choices involving ex ante registration. Moreover, if $k \leq \bar{k}$, the firm would not want to deviate and reveal its price and commit to it before consumers have to make their registration choice. If $k$ is, however, slightly above $\bar{k}$, then it would be in the interest of the firm to commit to a price together with its platform choice. By committing to a price slightly below $p^R$, it could guarantee that the consumers register ex ante even in case of $k > \bar{k}$. Another way of enlarging the range of registration cost for which consumers register is the use of discounts or store credit; in Section 4 we demonstrate the effectiveness of such discounts even when commitment on prices is not possible.

\(^{19}\)Since marginal production cost are assumed to be zero, all consumers with $\theta > k$ should buy in the welfare optimum, but in case of no ex ante registration, consumers buy only if $\theta > p^{NR} + k$. 

10
3 Competition

In the case of a monopoly firm in the previous section, the firm benefits from requiring ex ante registration, but the consumers would prefer that the firm does not require ex ante registration. Therefore, firms that do not require ex ante registration may attract (some of) the consumers and change firm 1’s platform choice.

To analyze the impact of competition on firm 1’s optimal platform choice, suppose that the incumbent firm 1 competes with a second firm 2. Both firms 1 and 2 produce the product at marginal cost of zero; a buyer’s valuation $\theta$ of this product is distributed according to $F$ and is the same for both firms’ products.

The mass of consumers consists of a share $\beta \in [0, 1]$ of ‘loyal’ consumers who buy only at firm 1 (or do not buy) and a remaining share $1 - \beta$ of non-committed consumers. The distribution $F$ of valuations is assumed to be the same across loyal and non-committed consumers. If a non-committed consumer is indifferent between trading (registering or buying) with firm 1 or firm 2, we assume that, with probability $\alpha \in [0, 1]$, he trades with firm 1.

The three-stage game of the previous section only needs slight modifications. In stage 1, firms 1 and 2 decide simultaneously and independently whether to require registration ex ante ($r_i = R$) or not ($r_i = NR$), and these decisions become common knowledge. In stage 2, firm $i \in \{1, 2\}$ chooses a price $p_i \geq 0$.

For stage 3, we have to distinguish between loyal and non-committed consumers. As in the previous section, loyal consumers decide whether to trade with firm 1. If firm 1 does not require ex ante registration, loyal consumers observe the price $p_1$ and their valuation $\theta$ and decide whether to buy. If firm 1 requires ex ante registration, loyal consumers decide whether to register at firm 1, in which case they learn $\theta$ and $p_1$ and may buy. Non-committed consumers observe the prices from the firms that do not require ex ante registration. Moreover, if there is a firm $i$ with $r_i = NR$, then non-committed consumers learn their valuation $\theta$. Non-committed consumers decide whether to register at firm 1 or firm 2 or both (if required by firm $i = 1, 2$) and decide whether and where to buy. As in the monopoly case, with

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$20$ Our main result generalizes to the case of more than two firms (see Remark 2 below).

$21$ For 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.

$22$ This tie breaking rule will be important for the equilibrium registration choices. (Intuitively, if firm 1 requires ex ante registration and $\alpha \rightarrow 0$, this yields a strong incentive for firm 2 to require ex ante registration as well and get all non-committed consumers.) We use this general specification since in our model with asymmetric firms no specific tie breaking rule seems particularly natural to assume.

$23$ To be precise, in case both firms require registration, when non-committed consumers register at firm
ex ante registration consumers incur a cost \( k > 0 \) before learning the firm’s price if they decide to register at this firm; without ex ante registration, the cost \( k \) is incurred only if the consumer decides to buy.

**Ex ante registration required by at least one firm** If at least one firm requires ex ante registration, the equilibrium choices in the respective continuation game are very similar to the monopoly case above. First, the candidate equilibrium price of a firm \( i \in \{1, 2\} \) that requires ex ante registration is \( p_i = p^R \) where \( p^R \) is defined as in (3). If a share of (loyal or non-committed) consumers is willing to register at firm \( i \) and a buyer’s valuation is distributed according to \( F \), the profit-maximizing price for firm \( i = 1, 2 \) is equal to \( p_i = p^R \), as in the monopoly case. Anticipating this price (requiring a buyer’s beliefs to be consistent with the firm’s choice), a necessary condition for a consumer registering at firm \( i \) is \( k \leq \bar{k} \) where \( \bar{k} \) is the buyer’s expected surplus conditional on registration at firm \( i \) (disregarding the registration cost) and defined in (4).\(^{24}\)

Second, the candidate equilibrium price of a firm \( i \in \{1, 2\} \) that does not require ex ante registration is \( p_i = p^{NR} \) given by (1), as in the monopoly case for \( r = NR \). Since \( p^{NR} < p^R \) (compare Remark 1), non-committed consumers anticipate that the other firm (which requires ex ante registration) charges a higher price, and they prefer to trade with firm \( i \). Thus, \( p_i = p^{NR} \) is also the optimal price if the other firm requires ex ante registration.

As in the previous section, define by

\[
\pi^R := \max_p \left( 1 - F(p) \right) p 
\]

the profit of firm \( i \) if it requires ex ante registration, chooses the price \( p_i = p^R \), and a mass one of consumers registers at firm \( i \) (and buys if \( \theta \geq p \)). Moreover, define by

\[
\pi^{NR} := \max_p \left( 1 - F(p + k) \right) p 
\]

the profit of firm \( i \) if it does not require ex ante registration, chooses the price \( p_i = p^{NR} \), and a mass one of consumers considers buying at firm \( i \) (and buys if \( \theta \geq p + k \)).

The equilibrium of the continuation games depending on the stage 1 platform choices can be summarized as follows. Suppose first that both firms 1 and 2 choose an ex ante registration requirement. Then, \( p_1 = p_2 = p^R \). If \( k \leq \bar{k} \), then all loyal consumers register at

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\(^{24}\) There are again subgame equilibria in which consumers believe that one of 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.
Expected profits \((\pi_1, \pi_2)\) in the continuation games

<table>
<thead>
<tr>
<th>Firm 1</th>
<th>Firm 2</th>
</tr>
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<tbody>
<tr>
<td>(r_1 = R)</td>
<td>(r_2 = R)</td>
</tr>
<tr>
<td>(((\beta + \alpha (1 - \beta)) \pi_R, (1 - \alpha) (1 - \beta) \pi_R))</td>
<td>((\beta \pi_R, (1 - \beta) \pi^{NR}))</td>
</tr>
<tr>
<td>(r_1 = NR)</td>
<td>(r_2 = NR)</td>
</tr>
<tr>
<td>((\pi^{NR}, 0))</td>
<td>((\beta \pi^{NR}, \beta (1 - \beta) \pi^{NR}))</td>
</tr>
</tbody>
</table>

Note: \(\pi^{NR}\) is defined as in (6). If \(k \leq \bar{k}\), then \(\pi^R\) is defined as in (5); otherwise, \(\pi^R = 0\).

Table 1: Summary of the firms’ expected profits conditional on the stage 1 platform choices.

Firm 1. Non-committed consumers are indifferent between ex ante registration at firm 1 or at firm 2; hence, a share \(\alpha\) of them registers at firm 1 and the remaining share \(1 - \alpha\) registers at firm 2. Taking into account the total share of consumers who register, this yields a profit of \((\beta + \alpha (1 - \beta)) \pi_R\) for firm 1 and a profit of \((1 - \alpha) (1 - \beta) \pi_R\) for firm 2. If \(k > \bar{k}\), then no consumer registers and the firms make zero profits.

Now suppose that firm 1 chooses \((r_1, p_1) = (R, p^R)\) and firm 2 chooses \((r_2, p_2) = (NR, p^{NR})\). Then loyal consumers register at firm 1 in case of \(k \leq \bar{k}\) and do not register (buy) otherwise. Since \(p_2 < p_1\), non-committed consumers only consider buying at firm 2 and buy if and only if \(\theta \geq p^{NR} + k\). Therefore, firm 1’s expected profit is \(\beta \pi_R\), while firm 2 gets \((1 - \beta) \pi^{NR}\).

Finally, if firm 1 chooses \(r_1 = NR\) and firm 2 chooses \(r_2 = R\), then no consumer registers/buys at firm 2, but all consumers only consider buying at firm 1 (at the price \(p_1 = p^{NR}\)). This yields an expected profit of \(\pi^{NR}\) for firm 1. The firms’ expected profits in these three continuation games for given platform choices \((r_1, r_2)\) are summarized in Table 1.

**No ex ante registration**  It remains to analyze the continuation game in case no firm requires ex ante registration in stage 1. Here, non-committed consumers observe both firms’ prices before making their buying decision in stage 3. Therefore, if the share \(\beta\) of loyal consumers is equal to zero, price competition between the firms in stage 2 results in prices being equal to zero (marginal cost). For \(\beta > 0\), however, the structure of the equilibrium changes since firm 1 can obtain positive expected profits by choosing a price \(p_1 > 0\) and selling to its loyal consumers only. As best response to \(p_2 = 0\), firm 1 will choose \(p_1 = p^{NR}\) and get an expected profit of \(\beta \pi^{NR} > 0\). If \(p_1 = p^{NR}\), however, firm 2 strictly prefers to sell to the non-committed consumers at a price just below \(p_1\). In the appendix, we show that
the equilibrium price setting decisions are in mixed strategies, leading to price dispersion in equilibrium.\footnote{The equilibrium of Bertrand price competition with a share of loyal consumers has been derived and applied by Narasimhan (1988), and similar structures have been analyzed, for instance, in the context of price competition with informed and uninformed consumers (Varian 1980; Baye, Kovenock, and de Vries 1992).}

**Lemma 1** Suppose that, in stage 1, no firm requires ex ante registration. Then, equilibrium expected profits are

\[ \pi_1 = \beta \pi^{NR} \quad \text{and} \quad \pi_2 = \beta (1 - \beta) \pi^{NR} \]

where \( \pi^{NR} \) is given in (6).

Whenever the share of loyal consumers \( \beta > 0 \), both firms obtain a strictly positive profit in case both do not require ex ante registration. Intuitively, the competition between the firms is weakened: The incumbent firm 1 would rather not want to lower its price too much because it then also loses profit it can make when selling to its loyal customers only (at a higher price). Therefore, firm 2 can also sell at prices above zero and make positive profits.

Since the share of loyal customers determines firm 1’s “outside option” (it can always offer a price \( p^{NR} \) and sell only to these buyers), the expected profit of firm 1 is increasing in \( \beta \). In fact, firm 1’s expected equilibrium profit in this continuation game is exactly equal to its profit when choosing \( p_1 = p^{NR} \) and selling only to the loyal buyers. The expected profit of firm 2, however, is non-monotone in \( \beta \). Intuitively, for small \( \beta \), firm 2 benefits from an increase in \( \beta \) because makes firm 1’s pricing strategy “less aggressive.” For large \( \beta \), however, this positive effect is outweighed by the direct negative effect that a higher \( \beta \) reduces the share of consumers that firm 2 can potentially sell to.

**Equilibrium** The equilibrium platform choices of the firms follow directly from the firms’ continuation payoffs conditional on the registration requirements, as summarized in Table 1.

**Proposition 2** Consider the firms’ stage 1 platform choices and let \( \bar{k} \) be given as in (4). Moreover, suppose that \( \beta > 0 \) and

\[ \alpha > \bar{\alpha} := \frac{\pi^R - \pi^{NR}}{\pi^R}. \] (7)

(i) If \( k \leq \bar{k} \), then, in equilibrium, firm 1 requires ex ante registration and firm 2 does not require ex ante registration.
(ii) If \( k > \bar{k} \), then, in equilibrium, both firms do not require ex ante registration.

**Proof.** See appendix. ■

Proposition 2 reinforces the result for the monopoly case: For sufficiently small cost of registration, firm 1 prefers to require ex ante registration. This preference is strict for any \( \beta > 0 \); hence, an infinitesimally small share of loyal consumers makes it strictly better for firm 1 to require ex ante registration. The reason is that, by requiring ex ante registration, the incumbent firm 1 can avoid the “fierce competition” with firm 2 but sell at higher prices.

As a best reply, firm 2 will not require ex ante registration and gain all the non-committed customers, unless the tie breaking rule for indifferent consumers has a strong bias towards firm 2 (that is, \( \alpha \) is very small; compare the condition in (7)).\(^{26}\) To see why, suppose that \( \alpha \to 0 \), which means that all indifferent consumers will shop at firm 2. Then, if both firms require ex ante registration, all non-committed consumers will shop at firm 2.\(^{27}\)

Interestingly, the equilibrium in which firm 1 requires ex ante registration exists for all \( \beta \geq 0 \), that is, it does not depend on there being a (sufficiently high) share of loyal consumers. While it is the unique equilibrium in case of \( \beta > 0 \) (as in Proposition 2(i)), there are additional equilibria in case \( \beta = 0 \): Here, firm \( i \in \{1, 2\} \) is indifferent between \( r_i = R \) and \( r_i = NR \) if firm \( j \) chooses not to require ex ante registration, which results in multiple equilibria.\(^{28}\)

To conclude this section, we briefly discuss how our main insight generalizes to the case where the incumbent firm has multiple competitors.

**Remark 2** Suppose that there are \( n \) firms. A share \( \beta \in [0, 1) \) of consumers only considers buying at firm 1. Then, if \( k \leq \bar{k} \), there is an equilibrium in which firm 1 requires ex ante registration and firms 2, ..., \( n \) do not require ex ante registration.

If the incumbent firm 1 has more than one competitor which do not require ex ante registration, Bertrand competition between those competitors will result in prices \( p_2 = \ldots = p_n = 0 \). In this case, it is optimal for firm 1 to require ex ante registration and to sell at \( p_1 = p^R \) to its loyal consumers, which yields a profit of \( \beta \pi^R \) (if \( k \leq \bar{k} \)).

\(^{26}\)Note that the threshold \( \bar{\alpha} \) in (7) is only relevant for the equilibrium if \( k \leq \bar{k} \), and it is lower the lower \( k \) and converges to zero if \( k \to 0 \). Hence, the lower \( k \), the larger is the range of tie breaking rules for which the equilibrium is as in Proposition 2. For instance, if \( F \) is the uniform distribution on \([0, 1]\), then it can easily be verified that \( \pi^R = 1/4, \pi^{NR} = (1-k)^2/4 \), and \( \bar{k} = 1/8 \). Hence, we get \( \bar{\alpha} = k (2-k) \) which approaches zero if \( k \to 0 \) and approaches 15/64 if \( k \to k \). For all tie breaking rules with \( \alpha > \bar{\alpha} \), the unique equilibrium is \((r_1, r_2) = (R, NR)\) for all \( \beta > 0 \).

\(^{27}\)The equilibrium platform choices then depend on firm 1’s best reply to \( r_2 = R \). In fact, if (7) is violated, then, depending on the underlying parameter values, the equilibrium is either \((r_1, r_2) = (R, R)\) or in mixed strategies where both firms randomize between \( R \) and \( NR \).

\(^{28}\)For details see the proof of Proposition 2 in the appendix.
that \((r_1 = R, r_2 = \ldots = r_n = NR)\) is an equilibrium independent of any tie breaking rule for indifferent consumers: If, for instance, firm 2 deviates and requires ex ante registration, then none of the consumers will trade with firm 2 but all non-committed consumers will buy at one of the firms 3,\ldots,\,n. Hence, the prediction in Proposition 2(i) becomes more robust if the number of competitors increases.

4 Discount policies and registration

Discounts (store credit) offered conditional on buying are a widely used instrument in internet markets. This section analyzes how discounts affect the consumers’ registration decision and hence the firm’s platform choice.

If a firm requires ex ante registration but offers price discounts to registered consumers, this affects the firm’s equilibrium pricing decision, which is anticipated by the consumers. 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.\footnote{Recall that in case of ex ante registration requirement the price is observed by consumers only after they have registered.} Therefore, in a model in which all consumers have the same registration cost, discounts have no net effect: With homogeneous registration cost, all of the consumers who register (or none of them) must have been offered a discount.\footnote{The firm would only use discounts in case of \(k > \bar{k}\) 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.} But discounts have an effect when consumers differ in their concerns about registration, which is a reasonable assumption. Therefore, we first analyze a monopoly firm’s platform choice and pricing decision for the case of heterogeneity in registration cost. This also serves as a robustness check for the results on equilibrium platform choices derived in the previous sections. Then, we show that firms can use discounts to increase the share of consumers who register even if consumers anticipate the price effect of discount policies.

**Heterogeneity in registration cost**  Consider again the monopoly case and suppose there are two types of consumers: high-cost consumers with registration cost \(k = k_H\) and low-cost consumers with \(k = k_L\), with

\[
\Pr(k = k_L) = q \quad \text{and} \quad \Pr(k = k_H) = 1 - q, \quad 0 < k_L < k_H.
\]

We assume that cost of registration \(k\) and consumer valuation \(\theta\) are independently distributed. The interesting case is the one where only low-cost consumers are willing to register, that is, \(k_L < \bar{k} < k_H\) (where \(\bar{k}\) is defined in (4)).
Proposition 3 Suppose that $0 < k_L < \bar{k} < k_H$. Then, there exists a threshold $\bar{q} \in (0, 1)$ for the share of low-cost consumers such that the monopoly firm requires ex ante registration if and only if $q \geq \bar{q}$.

Proof. See appendix. ■

If the share $q$ of low-cost consumers is sufficiently large, then the firm requires ex ante registration, accepting that only low-cost consumers register and high-cost consumers do not.\(^{31}\) In other words, the firm prefers an ex ante registration requirement whenever the larger profit it gets from selling to the low-cost consumers outweighs the loss in profits from not selling at all to the high-cost consumers.

Use of discounts (store credit) Suppose now that the firm offers a discount $d$ (store credit) to a share $\delta$ of consumers. The discount 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.

The firm’s incentive for offering discounts depends on the degree to which it is able to target the discount to consumers who would not register without discount. In one extreme case, the discounts are offered purely randomly to a share $\delta$ of consumers. In the other extreme case, the firm is able to restrict the offer of a discount to consumers with high registration cost, that is, the discounts can be perfectly targeted to the high-cost consumers.\(^{32}\) To illustrate that discounts can make ex ante registration requirements more profitable, we analyze the “worst case” for the firm, which is the case of random discounts: A discount $d > 0$ is offered to a random share $\delta$ of the consumers, not conditioning on their (unobservable) registration cost.\(^{33}\)

Consider the modified game in which the firm chooses and announces a discount policy $(d, \delta)$ 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 $d$. We focus on

\(^{31}\)If $k_L \to 0$, then $\bar{q} \to 1$: Intuitively, if $k_L = 0$, registration is irrelevant for the low-cost types. Thus, if the firm does not require ex ante registration, it can choose $p = p^R$ and get the same profit from selling to the low-cost types than if it requires ex ante registration and only the low-cost types register. But in case of $r = NR$, it might also sell to some high-cost types; hence, requiring ex ante registration can never be strictly preferred in the limit case of $k_L = 0$ when $k_H > \bar{k}$.

\(^{32}\)In reality, targeting will be typically imperfect, even though firms do certainly better than just randomly offering discounts, for instance, by attaching discounts to certain consumer characteristics or previous purchases that they can observe and that they expect to be correlated with the registration cost.

\(^{33}\)Note that, if the firm does not require ex ante registration, it will not offer a random discount: Intuitively, discounts which are randomly offered to a share of the customers distort the firm’s price choice and, thus, reduce the expected profit. Note further, however, that targeted discounts, having the same effect as price discrimination, can increase the firm’s profit even when it does not require ex ante registration.

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the case of heterogeneity in registration cost with \( k_L < \bar{k} < k_H \) such that consumers with high registration cost do not register if no discounts are offered.

Suppose that all low-cost consumers register independently of whether they are offered a discount, but high-cost consumers register if and only they are offered a discount. Then, the firm’s expected profit for a given discount policy \((d, \delta)\) is

\[
\pi^R_d (p) := (1 - \delta) q (1 - F(p)) p + \delta (1 - F(p - d)) (p - d).
\]

This profit function takes into account (i) that a share \((1 - \delta) q\) of consumers register without having a discount (all being low-cost types) and may buy at price \(p\) and (ii) that a share \(\delta\) of consumers register with discount and may buy at an effective price \(p - d\). For all \(\delta \in (0, 1)\), the price \(p^R_d\) which maximizes \(\pi^R_d\) in (8) fulfills

\[
p^R_d - d < p^R < p^R_d.
\]

The optimal price net of discount \((p^R_d - d)\) is smaller than the price \(p^R\) without discounts, but the posted price \(p^R_d\) is increased.\(^{34}\) 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 \(p^R\) to registered consumers, the firm sells at effective prices \(p^R_d - d < p^R\) and \(p^R_d > p^R\) to consumers with discount and without discount, respectively.

Anticipating the effective price \(p^R_d - d\), high-cost consumers with discount register if and only if

\[
\int_{p^R_d - d}^{\infty} (\theta - (p^R_d - d)) \, dF(\theta) \geq k_H.
\]

Moreover, low-cost consumers without a discount register if and only if

\[
\int_{p^R_d}^{\infty} (\theta - p^R_d) \, dF(\theta) \geq k_L.
\]

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 (9) is increasing in \(d\). The firm will choose \(d\) such that (9) holds with equality; due to the price distortion effect, the firm will not increase the discount any further.) Since \(p^R_d\) depends on the share \(\delta\) of consumers with discount, \(d\) can be expressed as a continuous function of \(\delta\).\(^{35}\) Note that the discount

\(^{34}\)This result is similar to Remark 1 on the comparison of \(p^R\) and \(p^{NR}\). More precisely, \(p^R_d\) is increasing in \(d\) and \(p^R_d - d\) is decreasing in \(d\), which can be verified by implicit differentiation of the first order condition characterizing \(p^R_d\), given the assumptions on \(F\).

\(^{35}\)For general distributions \(F\) no closed form solution for \(d\) can be obtained; for a uniform distribution on \([0, 1]\), for instance, we obtain \(d(\delta) = \frac{\delta + (1 - \delta) \bar{k}}{2(1 - 3\bar{k})} (\sqrt{k_H / \bar{k}} - 1)\) for \(k_H \geq \bar{k} = 1/8\).
$d(\delta)$ necessary to induce high-cost types to register is increasing in $\delta$ since the price $p^R_d$ also increases in $\delta$: 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.\footnote{This again follows from implicit differentiation and the assumptions on $F$. If $\delta \to 1$, then $p^R_d \to p^R + d$: If all registered consumers have a discount, then 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 consumers all have the same registration cost and only consumers with discount register, then again the $p^R_d = p^R + d$ and there is no effect of offering discounts.}

**Proposition 4** Suppose that $k_L < \bar{k} < k_H$ where $\bar{k}$ is defined as in (4). If $k_H$ is sufficiently close to $\bar{k}$, then 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.

**Proof.** See appendix. □

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 4 is as follows. When $k_H$ is close to $\bar{k}$, only a small discount is needed in order that high-cost consumers with discount register. The firm can give such a small discount to almost all consumers. Then the price $p^R_d$ is close to $p^R$; thus all low-cost consumers will register, including those who have not received a discount. Moreover, the price distortion effect is small. Therefore, the profit of the firm is almost equal to $\pi^R$. The proof of Proposition 4 shows that for any fixed $\delta \in (0,1)$, the firm’s profit converges to $q\pi^R + \delta (1-q) \pi^R$ if $k_H \to \bar{k}$ (where $\pi^R$ is given in (5)). Thus the firm can achieve a profit that is close to $\pi^R$ when $k_H$ is close to $\bar{k}$.

The case of purely random discounts is the most unfavorable case for a firm which requires ex ante registration. The better the firm is able to target the discounts, the less costly becomes the use of discounts, and the more attractive becomes the ex ante registration policy with discounts.

**Remark 3** The firm’s incentive to use a discount policy is stronger the better the firm is able to target the discounts to high-cost consumers.

The intuition behind Remark 3 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).
5 Conclusion

This paper highlights an important aspect of online shopping: When buying at online shops, consumers incur a non-monetary ‘registration cost’ caused 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. We show that firms have an incentive to shift this 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. Intuitively, making the registration cost sunk at the point in time when consumers decide to buy increases the consumers’ willingness to buy, for instance, when credit card information is already entered and stored in the consumer’s user account.

To demonstrate this mechanism, we consider a model in which the 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 to play a role in this market. Firms decide only 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.

In the baseline model 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 benefits from requiring registration at an early stage. Moreover, we show that the firms’ incentives to require ex ante registration carry over to the case of competition between firms. 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 not advisable for firms with no loyal consumers. They compete for the non-committed consumers and achieve higher profits when they abstain from ex ante registration requirements and reduce the amount of personal information to be revealed by consumers ex ante, respectively.

For incumbent firms with loyal consumers, ex ante registration requirements may deter some consumers from trading with the firm. We show that discounts (store credit) offered conditional on buying can increase the share of consumers who are willing to register even though consumers anticipate that such discount policies affect the equilibrium price charged
by the firm. Therefore, offering discounts to a share of consumers can be beneficial to the firm, in particular if it cannot directly influence the registration cost, as assumed in our model. Whether the firm would, in fact, want to influence the consumers’ cost of registration depends on the value which firms derive from having consumers signing in (for instance, from obtaining additional information about 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 the consumers considers to buy since privacy concerns are also caused by data collection and the use and abuse of personal information by third parties. However, firms’ strategies that lower the registration cost can increase the number of customers of a firm which requires ex ante registration. Taking into account that the registration cost (the amount of information provided) of consumers who register anyway would then also reduced, optimal platform design with endogenous cost of registration will reflect the trade-off between the value of information and the profit from selling to additional consumers, which we also expect to depend on the degree of competition and consumer brand loyalty.

A Appendix

A.1 Consumer surplus with ex ante registration: an example

In this appendix we show that the price may be lower, and consumer surplus may be higher, if the firm requires ex ante registration than if it does not. Suppose that $F$ is a two-point distribution where a fraction $\lambda \in (0, 1)$ of consumers has a low valuation $\theta = l \geq 0$, and a fraction $1 - \lambda$ has a high valuation $\theta = h > l$. Assume that

\begin{align}
(1 - \lambda) h &< l < (1 - \lambda) h + \lambda k, \\
k &< (1 - \lambda) (h - l).
\end{align}

Clearly, there is an open set of parameters that satisfy these assumptions; for example, they hold when $h = 11$, $l = 6$, $\lambda = 1/2$, and $k = 2$, and in a sufficiently small environment. Note also that the first inequality in (11) together with (12) implies that $l > k$. Therefore, first best efficiency requires that all consumers receive the product.

Suppose the firm requires ex ante registration. Given the two-point distribution of consumers valuations, only the prices $p = l$ and $p = h$ can be profit-maximizing. At $p = l$, all registered consumers buy, and profit is equal to $l$ per registered consumer; at $p = h$, only the high valuation types buy, leading to a profit of $(1 - \lambda) h$ per registered consumer.
By assumption (11), the firm prefers to set $p = l$. Anticipating this price, a consumer’s expected utility from registering is $(1 - \lambda)(h - l) - k > 0$ by assumption (12); thus all consumers register. The firm’s profit is equal to $\pi^R = l$; consumer surplus is equal to $CS^R = (1 - \lambda)(h - l) - k > 0$.

Suppose the firm does not require ex ante registration. Then, the profit-maximizing price is either $h_k$ or $l_k$. At $p = h_k$, only the high types buy, and expected profit is $(1 - \lambda)(h_k)$. At $p = l_k$, all consumers buy and the profit is $l_k$. By the second inequality in (11), the firm prefers to set $p = h_k$ and achieves a profit $\pi^{NR} = (1 - \lambda)(h_k)$. Consumer surplus is equal to $CS^{NR} = 0$. Note that the price is higher if the firm does not require ex ante registration since $h_k > h_k = (1 - \lambda > l$, where the second inequality follows from assumption (12).

The first inequality in (11) implies that $\pi^R > \pi^{NR}$; thus the firm strictly prefers to require registration. Moreover, consumers also strictly prefer that the firm requires registration. Hence, in this example, requiring ex ante registration is a Pareto improvement when compared to a situation where requiring ex ante registration is banned by law.\footnote{Under the assumptions (11) and (12), the allocation is first best under an ex ante registration requirement, while it is not without ex ante registration requirement. This feature is not crucial, however. To see this, suppose that a small fraction $\varepsilon$ of consumers have a valuation $u \in (k, l)$, whereas a fraction $\lambda - \varepsilon/2$ has valuation $l$, and $1 - \lambda - \varepsilon/2$ has valuation $h$. First best efficiency requires type $u$ to buy since $u > k$. If $\varepsilon$ sufficiently small, and (11) and (12) hold, the profit-maximizing pricing will be as above, and the firm will not sell to type $u$, independent of the platform choice. Thus, the allocation is not first best, but nevertheless welfare is higher if the firm requires ex ante registration.}

### A.2 Proof of Lemma 1

Since both prices are common knowledge, non-committed buyer will buy (if at all) at the firm which chooses the lower price. Hence, for given prices $(p_1, p_2)$, the firms’ expected profits are

$$
\pi_1 = \begin{cases} 
(1 - F (p_1 + k)) p_1 & \text{if } p_1 < p_2 \\
(\beta + (1 - \beta) \alpha)(1 - F (p_1 + k)) p_1 & \text{if } p_1 = p_2 \\
\beta (1 - F (p_1 + k)) p_1 & \text{if } p_1 > p_2
\end{cases}
$$

and

$$
\pi_2 = \begin{cases} 
0 & \text{if } p_1 < p_2 \\
(1 - \beta)(1 - \alpha)(1 - F (p_2 + k)) p_2 & \text{if } p_1 = p_2 \\
(1 - \beta)(1 - F (p_2 + k)) p_2 & \text{if } p_1 > p_2
\end{cases}
$$

Suppose first that $\beta = 0$. Then, the firm with the lower price gets all consumers, and hence, $p_1 = p_2 = 0$ in equilibrium, with corresponding profits equal to $\pi_1 = \pi_2 = 0$.

Now suppose that $\beta > 0$. Then, if $p_2 = 0$, firm 1 strictly prefers $p_1 = p^{NR}$ over $p_1 = 0$:
Firm 1 makes zero profits when choosing \( p_1 = 0 \) but an expected profit of \( \beta \pi^{NR} > 0 \) when choosing \( p_1 = p^{NR} \); in the latter case, firm 1 gives up on all non-committed consumers and sells only to the loyal consumers (with a valuation \( \theta \geq p^{NR} \)). In fact, \( p_1 = p^{NR} \) is firm 1’s best response to \( p_2 = 0 \).

If \( \beta > 0 \), there is no equilibrium in pure strategies. To see why, suppose that \( p_1 = \tilde{p} > 0 \). Firm 2’s best reply is \( p_2 = p^{NR} \) if \( \tilde{p} > p^{NR} \) and \( p_2 = \tilde{p} - \varepsilon \) otherwise, \( \varepsilon > 0 \) infinitesimally small.\(^{38}\) 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 \( \beta \pi^{NR} > 0 \) by setting \( p_1 = p^{NR} \).

Thus, the equilibrium must be in mixed strategies. In any equilibrium, firms will not choose prices higher than \( p^{NR} \), which is the price a firm would choose in the absence of competition, or if the other firm’s price is higher. Using standard techniques in auction theory, it can be shown that, in the unique equilibrium, the firms randomize continuously on an interval \((p, p^{NR})\) with \( p < p^{NR} \); moreover, firm 1 places a mass point of size \( \beta \) at \( p_1 = p^{NR} \).\(^{39}\)

The equilibrium can most easily be derived using the transformation

\[
v_i(p) = (1 - F(p_i + k)) p_i, \quad i = 1, 2
\]

and defining the strategies in terms of \( v_i(p_i) \) instead of in terms of \( p_i \). Note that \( v_i(0) = 0 \), \( v_i(p^{NR}) = \pi^{NR} \), and \( v_i(p) \) is strictly increasing in \( p \) on \((0, p^{NR})\); thus, the inverse function \( v_i^{-1}(v) \) yields the price that corresponds to a choice of \( v_i \). Therefore, we can think of firms as choosing \( v_i \in [0, v(p^{NR})] \). Firm 1 maximizes

\[
\pi_1 = \begin{cases} 
\beta v_1, & v_1 > v_2, \\
(\beta + (1 - \beta) \alpha) v_1, & v_1 = v_2, \\
v_1, & v_1 < v_2,
\end{cases}
\]

and firm 2 maximizes

\[
\pi_2 = \begin{cases} 
(1 - \beta) v_2, & v_1 > v_2, \\
(1 - \beta)(1 - \alpha) v_2, & v_1 = v_2, \\
0, & v_1 < v_2.
\end{cases}
\]

With this transformation, in equilibrium, the firms’ mixed strategies are given by the

\(^{38}\)To be precise, due to the continuous strategy space, we have to interpret the best reply as an \( \varepsilon \)-best reply if \( \alpha > 0 \). If \( \alpha = 0 \), then, if \( p_1 = \tilde{p} \leq p^{NR} \), best reply is \( p_2 = \tilde{p} \).

\(^{39}\)Technically, \( p \) is obtained such that firm 1’s expected profit when choosing \( p = p^{NR} \) is exactly equal to its expected profit when choosing \( p = p^{NR} \) and selling only to its loyal buyers. Uniqueness of the equilibrium follows from the analysis in Narasimhan (1988).
cumulative distribution functions

\[ B_1 (v_1) = \begin{cases} 
1 - \frac{\beta \pi^{NR}}{v_1}, & \text{if } \beta \pi^{NR} \leq v_1 < \pi^{NR}, \\
1, & v_1 \geq \pi^{NR}, 
\end{cases} \]  \tag{13}

and

\[ B_2 (v_2) = \begin{cases} 
\frac{1}{1-\beta} - \frac{\beta \pi^{NR}}{(1-\beta)v_2}, & \text{if } \beta \pi^{NR} \leq v_2 < \pi^{NR}, \\
1, & v_2 \geq \pi^{NR}. 
\end{cases} \]  \tag{14}

The corresponding equilibrium payoffs are

\[ \pi_1 = \beta \pi^{NR}, \]
\[ \pi_2 = \beta (1-\beta) \pi^{NR}. \]

We now verify that this is an equilibrium. Consider firm 1 and suppose that firm 2 follows \( B_2 \). Since \( v_1 (p) = v_2 (p) \), if firm 1 chooses \( v_1 = v_1 (p_1) \), the probability that firm 2 chooses a lower price is equal to

\[ \Pr (p_2 < p_1) = \Pr (v_2 < v_1) = B_2 (v_1). \]

Therefore, firm 1’s expected profit from choosing \( v_1 = v_1 (p_1) \) is equal to

\[ \pi_1 (v_1) = B_2 (v_1) \beta v_1 + (1 - B_2 (v_1)) v_1. \]

If \( v_1 \in [\beta \pi^{NR}, \pi^{NR}] \), using (14), we get

\[ \pi_1 (v_1) = \left( \frac{1}{1-\beta} - \frac{\beta \pi^{NR}}{(1-\beta)v_1} \right) \beta v_1 + \left( 1 - \frac{1}{1-\beta} + \frac{\beta \pi^{NR}}{(1-\beta)v_1} \right) v_1 
\]

\[ = \beta \pi^{NR}. \]

If \( v_1 = \pi^{NR} \) (which corresponds to \( p_1 = p^{NR} \)), then \( B_2 (v_1) = 1 \) and only the loyal consumers consider buying at firm 1. Also in this case firm 1’s expected payoff is \( \beta \pi^{NR} \); hence, firm 1 is indifferent between all \( v_1 \in [\beta \pi^{NR}, \pi^{NR}] \). Moreover, all \( v_1 > \pi^{NR} \) \( (p_1 > p^{NR}) \) do not change the share of potential consumers, but lead to a strictly lower expected profit. Similarly, all \( v_1 < \beta \pi^{NR} \) lead to a strictly lower expected profit than \( v_1 = \beta \pi^{NR} \). Since \( B_2 (\beta \pi^{NR}) = 0 \), again the share of potential customers does not change, but firm 1 sells at a lower price.

By similar arguments, it can be shown that, given \( B_1 \), firm 2 is indifferent between all \( v_2 \in [\beta \pi^{NR}, \pi^{NR}] \) and strictly worse off for \( v_2 \notin [\beta \pi^{NR}, \pi^{NR}] \). In particular, for all
\[ v_2 \in [\beta \pi^N, \pi^R], \text{ using (13), we get} \]
\begin{align*}
\pi_2(v_2) &= (1 - B_1(v_2)) (1 - \beta) v_2 \\
&= \beta (1 - \beta) \pi^N.
\end{align*}

A.3 Proof of Proposition 2

First note that (7) implies that it is strictly dominant for firm 2 to choose \( r_2 = NR \). If \( r_1 = NR \), then firm 2 makes zero profits when choosing \( r_2 = R \) but strictly positive profits when choosing \( r_2 = NR \). If \( r_1 = R \), then firm 2 is strictly better off when choosing \( r_2 = NR \) if and only if
\[ (1 - \beta) \pi^N > (1 - \beta)(1 - \alpha) \pi^R \]
or, equivalently, if (7) holds. Second, since
\[ \beta \pi^R > \beta \pi^N \]
for all \( \beta > 0 \), firm 1’s best reply to \( r_2 = NR \) is to require ex ante registration. This shows part (i).

In part (ii), the profit of firm \( i \in \{1, 2\} \) is zero in case \( i \) requires ex ante registration but strictly positive if \( i \) does not require ex ante registration. Thus, in equilibrium, \((r_1, r_2) = (NR, NR)\).

For completeness, note that there are additional equilibria in the case without loyal consumers (\( \beta = 0 \)). First, suppose that \( \beta = 0 \) and \( k \leq \tilde{k} \). Then, comparing the profits in Table 1 shows that both \((r_1, r_2) = (R, NR)\) and \((r_1, r_2) = (NR, NR)\) is an equilibrium.\(^{40}\) Second, suppose that \( \beta = 0 \) and \( k > \tilde{k} \). If \( r_j = NR \), then firm \( i \in \{1, 2\} \) is indifferent between \( r_i = R \) and \( r_i = NR \), while, if \( r_j = R \), then \( i \) strictly prefers \( r_i = NR \). Thus, there are three equilibria: \((r_1, r_2) = (NR, NR), (r_1, r_2) = (R, NR)\), and \((r_1, r_2) = (NR, R)\).

A.4 Proof of Proposition 3

Note that if the firm requires ex ante registration, its profit is \( \hat{\pi}^R := q \pi^R \), where \( \pi^R \) is defined in (5). (The optimal price is still \( p^R \) as in (3) since it does not depend on the registration

\(^{40}\)If, in addition, \( \alpha < \pi^N / \pi^R \), then firm 1’s best response to \( r_2 = R \) is \( r_1 = NR \) while firm 2 is indifferent given that \( r_1 = NR \). Hence, if \( \alpha \in (\pi^R - \pi^N / \pi^R, \pi^NR / \pi^R) \) and this interval is non-empty (which requires \( \pi^NR / \pi^R > 1/2 \)), then there is a third equilibrium with \((r_1, r_2) = (NR, R)\).
Moreover, if the firm does not require ex ante registration, its profit is

\[ \tilde{\pi}^{NR} := \max_p \left( (1 - F(p + k_L)) p + (1 - q)(1 - F(p + k_H)) f \right) p. \]

The optimal price \( \hat{p}^{NR} \) which maximizes \( \tilde{\pi}^{NR} \) takes into account both types of consumers. If \( q = 0 \), then \( \tilde{\pi}^{NR} > \hat{\pi}^R = 0 \) since the share of consumers who register is zero. If \( q = 1 \), then

\[ \hat{\pi}^R = \pi^R = \max_p (1 - F(p)) p > \max_p (1 - F(p + k_L)) p = \tilde{\pi}^{NR}. \]

Moreover, since \( p^R \) is independent of \( q \) and using an envelope argument,

\[ \frac{\partial}{\partial q} (\hat{\pi}^R - \tilde{\pi}^{NR}) = (1 - F(p^R)) p^R - (1 - F(\hat{p}^{NR} + k_L)) \hat{p}^{NR} + (1 - F(\hat{p}^{NR} + k_H)) \hat{p}^{NR} > (1 - F(p^R)) p^R - (1 - F(\hat{p}^{NR})) \hat{p}^{NR} > 0. \]

Thus, there is a unique threshold \( \bar{q} \in (0, 1) \), which determines the firm’s platform choice.

### A.5 Proof of Proposition 4

For given \( d \) and \( \delta \), the price \( p^R_d \) that maximizes (8) is given by the first order condition

\[ \delta [-F'(p^R_d - d) (p^R_d - d) + 1 - F(p^R_d - d)] + (1 - \delta) q [-F'(p^R_d) p^R_d + 1 - F(p^R_d)] = 0. \]

(15)

Fix any \( \delta \in (0, 1) \) and let \( k_H \rightarrow \bar{k} \), holding \( \delta \) constant. Suppose the firm chooses the discount \( d \) such that (9) holds with equality. (If \( k_H \) is close to \( \bar{k} \), such a discount clearly exists.) Then, by (9), \( (p^R_d - d) \rightarrow p^R \). By definition of \( p^R \), it follows that

\[ [-F'(p^R_d - d) (p^R_d - d) + 1 - F(p^R_d - d)] 
\rightarrow 0. \]

By (15) this implies that

\[ [-F'(p^R_d) p^R_d + 1 - F(p^R_d)] 
\rightarrow 0, \]

which means \( p^R_d \rightarrow p^R \). Since \( (p^R_d - d) \rightarrow p^R \), we conclude that \( d \rightarrow 0 \).

Since \( p \rightarrow p^R \) if \( k_H \rightarrow \bar{k} \), the right hand side of condition (10) approaches \( \bar{k} \), which is by assumption strictly greater than \( k_L \). Therefore, (10) holds for \( k_H \) sufficiently close to \( \bar{k} \). Moreover, with \( k_H \rightarrow \bar{k} \), the profit (8) approaches

\[ \delta \pi^R + (1 - \delta) q \pi^R = q \pi^R + \delta (1 - q) \pi^R. \]
where $\pi^R$ is as defined in (5). For any $\delta > 0$, this is strictly greater than $\hat{\pi}^R = q\pi^R$, which is the profit the firm achieves when it requires ex ante registration and does not offer any discounts. This proves part (i).

For part (ii), without requiring ex ante registration, the firm’s profit equals $\hat{\pi}^{NR}$ given in the proof of Proposition 3. Note that

$$\pi^R = \max_p (1 - F(p)) p > \hat{\pi}^{NR} = \max_p q(1 - F(p + k_L)) p + (1 - q)(1 - F(p + k_H)) p.$$ 

Since $\pi^R$ does not depend on $k_H$ and $\hat{\pi}^{NR}$ is decreasing in $k_H$, there exists $\bar{\delta} < 1$ such that

$$q\pi^R + \delta (1 - q) \pi^R > \hat{\pi}^{NR}$$

for all $\delta > \bar{\delta}$ and all $k_H \geq \bar{k}$. Suppose the firm chooses $\delta \in (\bar{\delta}, 1)$. Then, for $k_H$ sufficiently close to $\bar{k}$, the profit from the discount scheme is sufficiently close to $q\pi^R + \delta (1 - q) \pi^R$ and hence strictly larger than $\hat{\pi}^{NR}$.

References


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