

# Strategic obfuscation and consumer protection policy\*

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## Abstract

This paper studies obfuscation decisions by firms. We show that more prominent firms are more likely to obfuscate. While prominent firms always choose maximum obfuscation, the obfuscation by less prominent firms depends on the degree of asymmetry in prominence and consumer protection policy. We evaluate the impact of a consumer protection policy that limits the scope of obfuscation. We show that such a policy may not be effective as less prominent firms may increase their obfuscation practice.

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# 1 Introduction

Consumer decision making is often imperfect. Consumers are susceptible to behavioral biases and suffer from cognitive limitations when evaluating competing offers. This has been documented for many markets, including for example, telecommunication markets (Miravete, 2013), electricity markets (Waddams and Wilson, 2010) and online auctions (Hossain and Morgan, 2006). It is then hardly surprising that firms try to exploit these biases and cognitive limitations by obfuscation strategies (Ellison and Ellison, 2009).

Retail financial markets are a prime example. Here, imperfect consumer decisions are well documented (e.g., Campbell, 2006; Calvet et al., 2009; Stango and Zinman, 2009, 2011) and there is robust evidence for strategies designed to take advantage of consumers' limited understanding. For instance, financial institutions might shroud certain elements of their pricing strategies (Gabaix and Laibson, 2006; Campbell, 2006) or highlight irrelevant information (Choi et al., 2010).<sup>1</sup> Firms take advantage of consumers' different information levels regarding price and product attributes leading to price dispersion for almost identical products (Christoffersen and Musto, 2002; Hortacsu and Syverson, 2004). Even worse, firms develop redundant "financial innovations" exclusively designed to attract naive consumers (Henderson and Pearson, 2011).

In this paper, we study whether policies to promote market transparency and to protect consumers are effective given that firms may choose to obfuscate. We focus on the impact of such policies in asymmetric settings: Firms, competing for retail customers, differ with respect to their level of prominence. The advantage of prominent firms is that they can attract a larger share of naive consumers who have difficulties comparing firms' offers.<sup>2</sup> In

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<sup>1</sup>Relying on outside advice may not help in making good decisions as this advice may be biased due to agency problems between financial institutions, their sales agents and consumers (Bolton et al., 2007; Inderst and Ottaviani, 2009, 2012; Woodward and Hall, 2012).

<sup>2</sup>In practice, different levels of prominence may arise for several reasons. For instance, an established incumbent may be viewed by consumers as more prominent and trustworthy than a newcomer firm. State-owned firms may enjoy greater levels of trust than their private competitors. Alternatively, prominence may arise due to higher marketing efforts or a better reputation of a firm. Similar in spirit, Armstrong et al. (2009b) and Rhodes (2011) consider a sequential search model where consumers search prominent firms first. Armstrong and Zhou (2011) investigate how firms can become prominent. Zhou (2011) analyzes the incen-

this setting, firms choose how much to obfuscate the market. We interpret obfuscation rather broadly and define it as to comprise all strategic actions that prevent some consumers to recognize the best offer. In this context, we are interested in the following questions. Which firms have more incentives to obfuscate, prominent firms or less prominent ones? What factors determine firms' obfuscation strategies? And most importantly, what are the effects of policies that aim at protecting consumers from obfuscation?

We analyze a two-stage game where two firms offer a homogeneous product and sell it to consumers. There are two types of consumers: sophisticated and naive consumers. Sophisticated consumers can perfectly evaluate the firms' offers and pick the better one. In contrast, naive consumers are not able to compare the two offers, and thus randomly choose one of the offers. However, consumers are biased towards one firm; naive consumers choose to buy from the more prominent firm with a larger probability. In this setting, firms have two decisions to make. In the first stage, firms simultaneously choose how much to obfuscate. By obfuscating more a firm can increase the number of naive consumers in the market, and the number of sophisticated consumers is accordingly decreased. In the second stage, firms—knowing how many naive and sophisticated consumers are in the market—compete in prices.

We demonstrate that the more prominent firm has, in general, larger incentives to obfuscate. In fact, we find that this firm always chooses maximal obfuscation. There are two reasons for this: First, by choosing obfuscation there are more naive consumers and those consumers are particularly likely to buy from the prominent firm. Due to this obfuscation the prominent firm can secure itself a large share of consumers. Second, more obfuscated markets are less competitive and, in consequence, prices and profits are higher. Both effects point to large incentives for prominent firms to engage in obfuscation. In contrast, for the less prominent firm the two effects may point in opposite directions and consequently this firm has less incentive to engage in obfuscation. On the negative side, this firm gives up consumers if it chooses to obfuscate as those now naive consumers are likely to buy from the competitor. This negative effect is more pronounced if the asymmetry in prominence is large. On the positive side, however, the less prominent

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tives of firms to become prominent in a model where consumers are reference-dependent.

firm benefits from weaker competition if the number of naive consumers is large. When determining its optimal level of obfuscation, the less prominent firm has to balance these two effects, and, under certain parameters the less prominent firm chooses an interior level of obfuscation. As a result, we show that obfuscation incentives by the less prominent firm is larger if the asymmetry in prominence is small as in this case the first effect is rather small.<sup>3</sup>

The key part of our analysis concerns the effects of a consumer protection policy aimed at increasing market transparency. We consider the introduction of consumer protection policies on the consumer side as well as on the firm side. On the consumer side, this could be, for instance, an educational programme to increase financial literacy. Consumers are less likely to be confounded by complex price structures if financial literacy is high. A firms-side intervention could be a disclosure policy that forces firms to disclose all possible fees or a cap on obfuscation possibilities such as limiting the length of the “footer” section of a credit card contract. Is such a consumer protection policy effective? Interestingly, our answer is that such a policy can be much less effective than expected. Indeed, under some circumstances such a policy is not effective at all. Introducing this policy has the intended effect on the prominent firm causing this firm to obfuscate less. However, the introduction of the policy has a second, unintended effect on the obfuscation decisions by the less prominent firm. In fact, we show that the less prominent firm has an incentive to increase obfuscation in response to such a policy. The reason for this effect is that due to the reduced obfuscation by the prominent firm the market has become more competitive than preferred by the non-prominent firm. In consequence, this firm increases its obfuscation efforts. In particular, any marginal reduction in the scope for obfuscation is completely offset by increased obfuscation from the non-prominent firm provided that the non-prominent firm chooses an interior level of obfuscation.

Our paper is related to the growing literature on behavioral industrial organization which studies the impact of competition in the presence of behaviorally biased or inattentive consumers.<sup>4</sup> Most closely to our paper, Carlin

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<sup>3</sup>Indeed, if firms enjoy identical levels of prominence both firms choose maximum obfuscation.

<sup>4</sup>See Huck and Zhou (2011) for a survey and Spiegler (2011) for a textbook.

(2009) studies how firms can exploit consumers' limited sophistication by obfuscation. This paper studies a symmetric oligopoly where firms—as in our paper—can increase the share of naive consumers. Most importantly, he shows that more competition in the form of more firms leads to more obfuscation.<sup>5</sup> We share the focus on obfuscation strategies; however, we consider an asymmetric setting caused by firm heterogeneity and show that asymmetry matters for the effectiveness of regulation. Policies that limit obfuscation are effective in symmetric markets but can be ineffective in asymmetric settings.

Piccione and Spiegler (2012) provide a framework of obfuscation where firms can choose different price frames, that when combined will result in different levels of comparability for consumers. In an earlier version, Piccione and Spiegler (2009), the authors also consider prominence by studying a version of their model where consumers who are unable to compare offers buy from the prominent firm (the incumbent, in their terminology). In equilibrium, the prominent firm minimizes comparability while the non-prominent firm (the entrant) does the opposite.<sup>6</sup> In contrast, we provide a model where the degree of prominence can be varied continuously. We also depart from this paper by studying the impact of consumer protection policies in such an asymmetric industry. Chioveanu and Zhou (2012) also provide an analysis where firms can obfuscate and earn positive profits in homogeneous goods markets if consumers are confused by different price frames. Spiegler (2013) provides a general duopoly framework that captures a variety of obfuscation strategies (shrouding product attributes, multi-dimensional pricing or framing in order to reduce product comparability).

Obfuscation may also arise if consumers are unable to evaluate all characteristics or price elements of a product. Spiegler (2006) considers a setup where consumers are confused by a multitude of price dimensions. Assuming a random sampling procedure by consumers, the paper shows that firms adopt a random pricing strategy with high prices in some dimensions

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<sup>5</sup>Carlin and Manso (2011) analyze, in a theoretical model, the timing of obfuscation. They show that small-scale education initiatives, leading to improved learning by naive consumers, may be offset by firms choosing to obfuscate more frequently, resulting in welfare losses and no improvement in market outcomes.

<sup>6</sup>This is also discussed in Spiegler (2011, Ch. 10.4).

and low prices along other dimensions. Gabaix and Laibson (2006) develop a model where consumers observe one price component (price of the base good), but are not aware of another component (the add-on). This leads to an equilibrium with low base-good and high add-on prices. Alternatively, obfuscation may also arise by firms manipulating search costs. Wilson (2010) and Ellison and Wolitzky (2012) analyze search models where firms can obfuscate by increasing consumers' search costs.

In the context of search markets, Armstrong et al. (2009a) and Armstrong (2012) argue that certain consumer protection policies such as limiting maximum prices can backfire and lead firms to raise their average prices. The intuition is that when prices are less dispersed under a price cap, fewer consumers will make the effort to become better informed, and hence firms face less competition. The present paper also argues that consumer protection policies can be ineffective. The mechanism is, however, different and we focus on obfuscation practices in asymmetric markets.

The remainder of the paper is organized as follows. In Section 2, we present our framework and theoretically analyze obfuscation decisions. Section 3 considers several extensions and modifications of our base model. Finally, Section 4 concludes.

## **2 A model of strategic obfuscation**

### **2.1 Model setup**

Consider a market where two firms compete to supply a homogeneous product. There is a mass one of consumers each demanding at most one unit of the product if the reservation price of  $r > 0$  is not exceeded. Consumers are either sophisticated or naive. Sophisticated consumers understand true offering prices and buy from the firm that offers the lowest price. A tie is broken with an equal probability. Naive consumers, on the other hand, are unable to compare prices and buy at random with a distribution to be specified below.

Shares of respective consumers are influenced by firms' obfuscation choices and the consumer protection policy. More complex pricing and a lower level

of consumer protection lead to more naive consumers and accordingly, to fewer sophisticated consumers. Let  $x \in (0, 1)$  be the level of the consumer protection policy and  $k_i \in [\underline{k}, \bar{k}] \subset \mathbb{R}_+$ ,  $i = 1, 2$ , the firms' obfuscation choices.<sup>7</sup>  $\underline{k}$  can be interpreted as no obfuscation at all and  $\bar{k}$  as full obfuscation. The proportion of *naive* consumers,  $\mu \in (0, 1)$ , is given by

$$\mu(x, k_1, k_2) = (1 - x)\theta(k_1, k_2), \quad (1)$$

where  $\theta : [\underline{k}, \bar{k}]^2 \rightarrow (0, 1)$  measures the effectiveness of firms' obfuscation practice in confusing consumers with  $\frac{\partial \theta}{\partial k_i} > 0$  for  $i = 1, 2$ . The proportion of *sophisticated* consumers is thus  $1 - (1 - x)\theta(k_1, k_2)$ .<sup>8</sup>

A larger  $x$  corresponds to a more stringent consumer protection policy and as a result there are fewer consumers susceptible to firms' obfuscation practice. To the extreme of a completely effective consumers protection policy ( $x \rightarrow 1$ ), firm obfuscation becomes irrelevant and standard Bertrand competition with only sophisticated buyers arises. For a given non-trivial level of consumer protection policy, the more a firm obfuscates, the more naive consumers there are as comparing prices becomes more difficult. Since price comparison requires an understanding of both offers, obfuscation by either firm strictly increases the share of naive consumers.

Equation (1) represents those consumer protection policies that act directly on consumers.<sup>9</sup> One example is education programmes aiming at raising financial literacy of consumers. With a more financially literate public, more consumers are capable of understanding complicated pricing terms and become immune to firm obfuscation.

When unable to compare prices, consumers often resort to factors like past experiences, firm reputation, name recognition, etc. Not all firms are identi-

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<sup>7</sup>An increase in the obfuscation parameter  $k_i$  might, for instance, correspond to the use of different terms and language—as can be observed in financial markets—which makes it harder for some consumers to fully understand pricing and, hence, impedes comparisons between different offers. Alternatively, an increase in obfuscation might also correspond to the number of price elements (as in mobile phone contracts) which may also make it harder for consumers to evaluate different offers and pick the best deal.

<sup>8</sup>We note that the results of the paper are robust to a slightly more general definition of naive consumers  $\mu = \theta(x, k_1, k_2)$  with  $\frac{\partial \theta}{\partial x} < 0$  and  $\frac{\partial \theta}{\partial k_i} > 0$ . However, the exposition is clearer using the multiplicative structure imposed in equation (1). Therefore, we present all results in term of (1), but emphasize that the intuitions regarding the results do not rely on this specific formulation.

<sup>9</sup>In Section 3.1, we discuss consumer protection policies that act directly on firms.

cal in these respects. In this paper we introduce asymmetry in prominence between the two firms to reflect this observation. Namely, Firm 1 is more prominent than Firm 2 and captures a larger share,  $\phi \in (\frac{1}{2}, 1)$ , of naive consumers. Firm 2 receives the rest of those naive consumers  $1 - \phi$ .<sup>10</sup>

We assume that both firms produce the product at constant marginal costs which, for simplicity, are normalized to zero. To focus on strategic effects among firms, the obfuscation choice is costless.<sup>11</sup>

The level of consumer protection is known to both firms at the beginning of this two-player game. In stage 1, the two firms simultaneously and independently decide on its own choice of obfuscation  $k_i$ . After knowing each other's obfuscation level, i.e., the share of naive consumers, they compete in prices in the second stage.<sup>12</sup> Both firms are standard profit maximizers.

## 2.2 Equilibrium prices

We start our analysis by writing out firm profits at the end of the game as functions of the share of naive consumers and the two prices. Suppose the share of naive consumers at the second stage is  $\mu$ . These consumers split between the two firms at a ratio of  $\phi : (1 - \phi)$  irrespective of prices. Sophisticated consumers, however, are drawn to the lower priced firm. Firm profits are hence

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<sup>10</sup>Note that we assume that naive consumers do not understand that, as it will later turn out, in equilibrium Firm 1 will charge a higher price than Firm 2 on average. This seems to be consistent with our notion of naiveness. Consumers who fail to recognize the best offer are also unlikely to consider that one firm might have a larger incentives for higher prices than another firm. Relatedly, we also assume that  $\phi$  is independent from price choices. That is, naive consumers are not able to compare different offers even if chosen prices are far apart.

<sup>11</sup>In Section 3.2 we consider the case where obfuscation is costly for firms.

<sup>12</sup>Note that in contrast to Carlin (2009) obfuscation and pricing decisions are sequential rather than simultaneous. That is, with sequential decisions, we assume pricing is more flexible while obfuscation tends to be more persistent. With simultaneous decisions, one would assume that price and obfuscation are joint decisions. Which assumption is more appropriate depends largely on the context. Assuming simultaneous move game would, however, lead to qualitatively similar structure of equilibrium obfuscation as under sequential moves. The prominent firm has larger incentives to obfuscate and would choose to obfuscate more often than the non-prominent firm. The reason is that the prominent firm charges on average a higher price than the less prominent firm and, hence, is more likely to benefit from obfuscation and a large number of naive consumers. Besides Carlin (2009), we refer the reader to Piccione and Spiegler (2012) where pricing and obfuscation decisions (in that case, framing of prices) are jointly determined.



$$\Pi_1(\mu, p_1, p_2) = \begin{cases} p_1 [\phi\mu + (1 - \mu)] & \text{if } p_1 < p_2 \\ p_1 \left[ \phi\mu + \frac{1-\mu}{2} \right] & \text{if } p_1 = p_2 \\ p_1\phi\mu & \text{if } p_1 > p_2 \end{cases} \quad (2)$$

and

$$\Pi_2(\mu, p_1, p_2) = \begin{cases} p_2(1 - \phi)\mu & \text{if } p_1 < p_2 \\ p_2 \left[ (1 - \phi)\mu + \frac{1-\mu}{2} \right] & \text{if } p_2 = p_1 \\ p_2 [(1 - \phi)\mu + (1 - \mu)] & \text{if } p_1 > p_2. \end{cases} \quad (3)$$

This second stage of the game is similar to Narasimhan (1988) although with a different interpretation: our naive consumers are known as loyal consumers in his paper.<sup>13</sup> Narasimhan (1988) shows that there exists no pure strategy pricing equilibrium. The unique equilibrium is in mixed strategies with Firm 1 having a mass point at  $r$  equal to  $\frac{(2\phi-1)\mu}{\phi\mu+(1-\mu)}$ .

**Lemma 1** (Narasimhan, 1988). For any given share of naive consumers,  $\mu \in (0, 1)$ , there exists a unique Nash equilibrium in the pricing stage, in which Firm 1 prices according to the cumulative distribution function

$$F_1(p) = \begin{cases} 0 & \text{if } p < p_0 \\ 1 + \frac{(1-\phi)\mu}{1-\mu} - \frac{\phi\mu(1-\phi\mu)}{[\phi\mu+(1-\mu)](1-\mu)} \frac{r}{p} & \text{if } p_0 \leq p < r \\ 1 & \text{if } p \geq r, \end{cases} \quad (4)$$

and Firm 2 prices according to the cumulative distribution function

$$F_2(p) = \begin{cases} 0 & \text{if } p < p_0 \\ 1 + \frac{\phi\mu}{1-\mu} - \frac{\phi\mu}{1-\mu} \frac{r}{p} & \text{if } p_0 \leq p < r \\ 1 & \text{if } p \geq r, \end{cases} \quad (5)$$

where

$$p_0 := \frac{\phi\mu r}{\phi\mu + (1 - \mu)} \quad (6)$$

is the lower bound of both firms' prices.

<sup>13</sup>The mass of naive consumers captured by Firm 1,  $\phi\mu$ , corresponds to Firm 1's loyal consumers  $\alpha_1$  in Narasimhan (1988). Likewise,  $(1 - \phi)\mu$  corresponds to Firm 2's loyal consumers  $\alpha_2$ , and  $(1 - \mu)$  to the remaining "switching" consumers  $\beta$ .

It can be shown that the more prominent Firm 1's price  $p_1$  first order stochastically dominates  $p_2$  (Narasimhan, 1988). Therefore, the less prominent Firm 2 on average charges a lower price. The reason is that the opportunity cost of competing for sophisticated consumers is higher for the more prominent firm as it loses more revenue than the other firm for each unit of price reduction due to its larger share of naive consumers. As a result of a lower price, sophisticated consumers are more likely to buy from the less prominent firm.

A rise in the share of naive consumers tends to soften price competition as there are less sophisticated consumers to compete for. That is, expected prices charged by both firms increase in  $\mu$ . This is shown formally in Appendix A.1.

### 2.3 Firm profits and consumer welfare

We note that only Firm 1's equilibrium strategy has a mass point at the reservation price  $r$ . By the fact that this is a mixed strategy equilibrium, Firm 1 expects to make the same profit as it would by selling only to its own share of naive consumers at the reservation price:

$$E(\Pi_1) = \phi\mu r. \quad (7)$$

Firm 2's expected profit can be found by inspecting the profit associated with  $p_2 \rightarrow r$ . In this case, Firm 2 expects to receive its own share of naive consumers as well as sophisticated consumers with a positive probability due to the mass point of Firm 1 at  $p = r$ .<sup>14</sup>

$$E(\Pi_2) = \left[ \underbrace{\frac{(2\phi - 1)\mu}{\phi\mu + (1 - \mu)}(1 - \mu)}_{\text{expected sales to sophisticated consumers}} + \underbrace{(1 - \phi)\mu}_{\text{sales to naive consumers}} \right] r, \quad (8)$$

which simplifies to

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<sup>14</sup>Alternatively, one can find Firm 2's expected profits by letting its price be  $p_0$  in which case it sells to its share of naive consumers and all sophisticated consumers.

$$E(\Pi_2) = \frac{(1 - \phi\mu)\phi\mu r}{\phi\mu + (1 - \mu)}. \quad (9)$$

Although the more prominent firm makes a profit equal to the level it could always make by focusing only on its own share of naive consumers, the less prominent firm's profit is higher than it would make by selling only to naive consumers as  $E(\Pi_2) > (1 - \phi)\mu r$ . This is due to the mass point of Firm 1 at  $p = r$  which means that Firm 2 sells to sophisticated consumers with a positive probability even if it charges a price close to  $r$  (see Eq. (8)). In this sense, the less prominent firm benefits from the presence of sophisticated consumers.

An increase in the share of naive consumers has three effects on a firm's profit. First, with more naive consumers market competition is lower and equilibrium price will be higher in the sense of first order stochastic dominance. Second, demand from sophisticated consumers declines.<sup>15</sup> Third, demand from naive consumers rises. The first and third effect are positive while the second is negative. For the prominent firm, the overall effect is strictly positive as it does not have an advantage in competing for sophisticated consumers in the first place. For the less prominent firm, the overall effect is unclear. Therefore, its obfuscation incentive can be different from its more prominent competitor.

As we consider a market for a homogeneous product, to determine consumer surplus, we only need to know total payments from consumers to firms.<sup>16</sup> These payments correspond to total industry profits equal to

$$E(\Pi_1) + E(\Pi_2) = \frac{\phi\mu r(2 - \mu)}{\phi\mu + (1 - \mu)}. \quad (10)$$

Consumer surplus is then expressed as  $E(CS) = r - [E(\Pi_1) + E(\Pi_2)]$ . Hence, consumer surplus and industry profits are inversely related. Eval-

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<sup>15</sup>However, it should be noted that the profit from selling to sophisticated consumers can also increase with  $\mu$ . This can be seen when considering Firm 2 profit at  $p_2 \rightarrow r$  as is shown in Eq. (8). Any increase in  $\mu$  raises the profit from sophisticated consumers whenever  $\mu < \frac{1}{2}$ . To see this consider that the sign of the derivative of sales to sophisticated consumers depends on the sign of  $1 - 2\mu + \mu^2(1 - \phi)$  which, for  $\phi \in (\frac{1}{2}, 1)$ , is guaranteed to be positive for any  $\mu < \frac{1}{2}$ .

<sup>16</sup>Note that total welfare is constant due to the assumption of inelastic demand. Prices are mere transfers between consumers and firms.

uating the impact of asymmetry and the share of naive consumers on consumer surplus yields:

**Lemma 2.** Consumer surplus decreases with  $\mu$  and  $\phi$ .

A rise in the share of naive consumers tends to soften competition in the sense that industry profits rise and consumer surplus falls, that is

$$\frac{\partial E(CS)}{\partial \mu} = -\frac{\phi r[2(1-\mu) + \mu^2(1-\phi)]}{[\phi\mu + (1-\mu)]^2} < 0. \quad (11)$$

Hence, to analyze whether policies are effective in increasing consumer surplus it is sufficient to analyze the impact on the share of naive consumers. A consumer protection policy is effective whenever the share of naive consumers is reduced.

Similarly, one can show that more asymmetric markets are also less competitive since with a larger share of naive consumers, the more prominent firm has higher opportunity costs in engaging in price competition if the asymmetry increases. As a result, consumer surplus decreases with  $\phi$ . This is formally shown by

$$\frac{\partial E(CS)}{\partial \phi} = -\frac{\mu r(2-\mu)(1-\mu)}{[\phi\mu + (1-\mu)]^2} < 0. \quad (12)$$

## 2.4 Equilibrium obfuscation

We are now in the position to analyze the firms' choices of obfuscation in the first stage. Since Firm 1's expected profit always increases in the share of naive consumers and increasing obfuscation raises the share of naive consumers, that is,

$$\frac{\partial E(\Pi_1)}{\partial k_1} = \phi r(1-x) \frac{\partial \theta}{\partial k_1} > 0, \quad (13)$$

Firm 1 wants to obfuscate as much as possible. Hence, its equilibrium choice of obfuscation is the highest  $k_1$ ,  $\bar{k}$ .

The impact of obfuscation on Firm 2's expected profit is more complicated:

$$\frac{\partial E(\Pi_2)}{\partial k_2} = [\phi(1 - \phi)\mu^2 - 2\phi\mu + 1] \frac{\phi r}{[\phi\mu + (1 - \mu)]^2} (1 - x) \frac{\partial \theta}{\partial k_2}. \quad (14)$$

Depending on asymmetry  $\phi$  and the share of naive consumers  $\mu$ , Firm 2 could find that an increase in its own obfuscation level increases or decreases its expected profit. As explained before, an increase in the share of naive consumers has three effects on Firm 2's expected profit. Firm 2 weighs an increased demand from naive consumers and a softened price competition against the associated decrease in the demand from sophisticated consumers when deciding on more obfuscation. For Firm 1, the positive effects of more obfuscation always dominate the negative effects because of a larger portion of naive consumers.

Let  $\underline{\mu}_x$  and  $\bar{\mu}_x$  be respectively defined as

$$\underline{\mu}_x = (1 - x)\theta(\bar{k}, \underline{k}) \quad \text{and} \quad \bar{\mu}_x = (1 - x)\theta(\bar{k}, \bar{k}).$$

For a given level of consumer protection  $x$  and with Firm 1 choosing  $\bar{k}$ , the share of naive consumers ranges from  $\underline{\mu}_x$  to  $\bar{\mu}_x$  when Firm 2 obfuscates from the levels of  $\underline{k}$  to  $\bar{k}$ . In other words,  $[\underline{\mu}_x, \bar{\mu}_x]$  is the set of consumer composition Firm 2 can achieve by choosing corresponding obfuscation levels given the policy environment  $x$  and Firm 1's optimal strategy  $\bar{k}$ . Also note that  $[\underline{\mu}_x, \bar{\mu}_x]$  is non-empty since  $\frac{\partial \theta}{\partial k_2} > 0$ .

The following proposition states equilibrium obfuscation.

**Proposition 1.** For a given combination of consumer protection policy  $x$  and asymmetry in prominence  $\phi$ , equilibrium obfuscation is as follows.

1. The more prominent Firm 1 chooses  $k_1^* = \bar{k}$ .
2. Define  $\tilde{\mu}(\phi) := \frac{\phi - \sqrt{\phi(2\phi - 1)}}{\phi(1 - \phi)}$ .
  - (a) If  $\tilde{\mu}(\phi) \geq \bar{\mu}_x$ , the less prominent Firm 2 chooses  $k_2^* = \bar{k}$ ;
  - (b) If  $\underline{\mu}_x < \tilde{\mu}(\phi) < \bar{\mu}_x$ , Firm 2 chooses the unique  $k_2^*$  such that  $\mu^* := (1 - x)\theta(\bar{k}, k_2^*) = \tilde{\mu}(\phi)$ ;
  - (c) If  $\tilde{\mu}(\phi) \leq \underline{\mu}_x$ , Firm 2 chooses  $k_2^* = \underline{k}$ .

**Proof:** see Appendix A.2.

The intuition behind this result is the following. If it were completely up to Firm 2, it would make the share of naive consumers be  $\tilde{\mu}(\phi)$  at which the positive and negative effects of a marginal change in  $\mu$  on Firm 2's expected profit balance out. However, the share of naive consumers is also influenced by consumer protection policy and Firm 1's choice of obfuscation. The range of  $\mu$  Firm 2 can choose from is hence only  $[\underline{\mu}_x, \bar{\mu}_x]$ . When the ideal  $\tilde{\mu}(\phi)$  is above  $\bar{\mu}_x$ , Firm 2 obfuscates fully to make  $\mu$  as close to  $\tilde{\mu}(\phi)$  as possible. When  $\tilde{\mu}(\phi)$  is below  $\underline{\mu}_x$ , even though Firm 2 would like to see an even larger share of sophisticated consumers, no obfuscation is the best it can do. Within the interval,  $\tilde{\mu}(\phi)$  is attainable and Firm 2 obfuscates accordingly.

With equilibrium obfuscation, we can derive the equilibrium share of naive consumers for a given combination of  $x$  and  $\phi$ .

**Proposition 2.** The share of naive consumers in equilibrium is

$$\mu^* = \begin{cases} \bar{\mu}_x & \text{if } \tilde{\mu}(\phi) \geq \bar{\mu}_x \\ \tilde{\mu}(\phi) & \text{if } \underline{\mu}_x < \tilde{\mu}(\phi) < \bar{\mu}_x \\ \underline{\mu}_x & \text{if } \tilde{\mu}(\phi) \leq \underline{\mu}_x. \end{cases} \quad (15)$$

## 2.5 Discussion

We note that  $\tilde{\mu}(\phi)$  as a function of  $\phi \in (\frac{1}{2}, 1)$  strictly decreases in  $\phi$  because

$$\frac{d\tilde{\mu}(\phi)}{d\phi} = -\frac{(1-\phi)^2 + \left(\phi - \sqrt{\phi(2\phi-1)}\right)^2}{2(1-\phi)^2\phi\sqrt{\phi(2\phi-1)}} < 0. \quad (16)$$

Since  $\lim_{\phi \rightarrow 1} \tilde{\mu}(\phi) = \frac{1}{2}$ ,  $\tilde{\mu}(\phi)$  ranges from 2 down to  $\frac{1}{2}$  as  $\phi$  goes from  $\frac{1}{2}$  up to 1. Note also that as  $\tilde{\mu}(\phi)$  strictly decreases in  $\phi$ , the inverse  $\tilde{\mu}^{-1}(\mu) : (\frac{1}{2}, 2) \rightarrow (\frac{1}{2}, 1)$  exists.

Based on the value of  $\tilde{\mu}(\phi)$ , further insights can be derived. First, for  $\phi \leq \frac{\sqrt{5}-1}{2} \approx 0.62$ ,  $\tilde{\mu}(\phi) \geq 1$ . In this region, as  $\bar{\mu}_x < 1$ ,  $\tilde{\mu}(\phi) > \bar{\mu}_x$  and Firm 2 obfuscates fully by Proposition 1.

**Remark 1.** If  $\phi \in \left(\frac{1}{2}, \frac{\sqrt{5}-1}{2}\right]$ ,  $k_2^* = \bar{k}$  and  $\mu^* = \bar{\mu}_x$ .

This result underpins the importance of asymmetry in studying firms' obfuscation incentives. If the two firms are sufficiently close in terms of prominence, both firms will fully obfuscate.

Second, for  $\phi > \frac{\sqrt{5}-1}{2}$ , the level of consumer protection policy  $x$  plays an important role in determining Firm 2's equilibrium obfuscation. For example, for a strong protection policy such that the share of consumers who are susceptible to obfuscation is below  $\frac{1}{2}$ ,  $\tilde{\mu}(\phi) > \bar{\mu}_x$  and by Proposition 1, Firm 2 obfuscates fully irrespective of  $\phi$ . When  $\bar{\mu}_x > \frac{1}{2}$ , under certain  $\phi$ ,  $\tilde{\mu}(\phi)$  is attainable and Case (2b) in Proposition 1 results.

- Remark 2.**
1. If  $\bar{\mu}_x \leq \frac{1}{2}$ , Firm 2 obfuscates fully irrespective of  $\phi$  and the equilibrium share of naive consumers is  $\bar{\mu}_x$  for all  $\phi \in (\frac{1}{2}, 1)$ .
  2. If  $\underline{\mu}_x \leq \frac{1}{2} < \bar{\mu}_x$ , Firm 2 obfuscates fully and the equilibrium share of naive consumers is  $\bar{\mu}_x$  for  $\phi \in (\frac{1}{2}, \tilde{\mu}^{-1}(\bar{\mu}_x))$ . For  $\phi \in [\tilde{\mu}^{-1}(\bar{\mu}_x), 1)$ , Case (2b) in Proposition 1 results.
  3. If  $\underline{\mu}_x > \frac{1}{2}$ , Firm 2 obfuscates fully and equilibrium share of naive consumers is  $\bar{\mu}_x$  for  $\phi \in (\frac{1}{2}, \tilde{\mu}^{-1}(\bar{\mu}_x))$ . For  $\phi \in [\tilde{\mu}^{-1}(\bar{\mu}_x), \tilde{\mu}^{-1}(\underline{\mu}_x)]$ , Case (2b) in Proposition 1 results. Firm 2 does not obfuscate and the equilibrium share of naive consumers is  $\underline{\mu}_x$  for  $\phi \in (\tilde{\mu}^{-1}(\underline{\mu}_x), 1)$ .

Figure 1 plots a situation covered by Part 3 of Remark 2 in which consumer protection policy  $x$  and the obfuscation effectiveness  $\theta$  lead to  $\underline{\mu}_x = 0.6$  and  $\bar{\mu}_x = 0.9$ . Although Firm 1 always obfuscates as much as possible, the obfuscation choice of Firm 2 stays at  $\bar{k}$  for  $\phi \in (0.5, 0.66]$ , gradually decreases in  $\phi$  to keep  $\mu^*$  at  $\tilde{\mu}(\phi)$  for  $\phi \in (0.66, 0.87)$ , and stays at  $\underline{k}$  for  $\phi \in [0.87, 1)$ .<sup>17</sup>

## 2.6 Comparative static predictions

There are two key parameters in the model, the degree of asymmetry in prominence, as measured by the parameter  $\phi$  and the level of consumer

<sup>17</sup>By equating  $\tilde{\mu}(\phi)$  to  $\bar{\mu}_x = 0.9$  and to  $\underline{\mu}_x = 0.6$  we find 0.66 and 0.87, respectively.

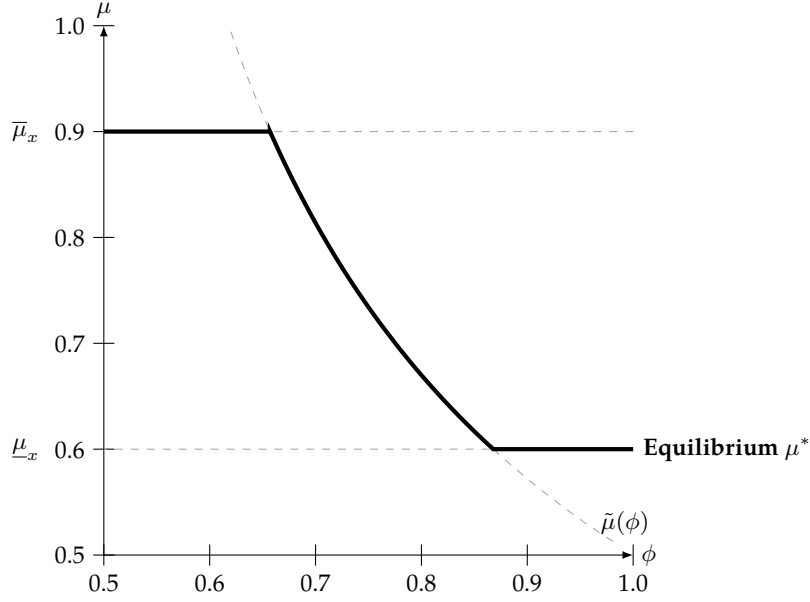


Figure 1: Equilibrium share of naive consumers as a function of asymmetry with  $\underline{\mu}_x = 0.6$  and  $\bar{\mu}_x = 0.9$

protection policy,  $x$ . This section provides the comparative static prediction on how equilibrium obfuscation is affected by these two parameters. Regarding these predictions we will focus on Firm 2's obfuscation choice as Firm 1 always chooses maximal obfuscation independent of the level of asymmetry and the consumer protection policy (Prop. 1).

In the example of Figure 1, we see Firm 2's equilibrium obfuscation choice and the equilibrium share of naive consumers decrease in asymmetry in certain interval of  $\phi$ . This in fact holds more generally.

**Proposition 3.** The less prominent Firm 2's equilibrium obfuscation choice and the equilibrium share of naive consumers weakly decrease in asymmetry:

1. If  $\tilde{\mu}(\phi) > \bar{\mu}_x$  or  $\tilde{\mu}(\phi) < \underline{\mu}_x$ , a marginal change in  $\phi$  does not change  $k_2^*$  and  $\mu^*$ ;
2. If  $\underline{\mu}_x < \tilde{\mu}(\phi) < \bar{\mu}_x$ ,  $k_2^*$  and  $\mu^*$  strictly decrease in  $\phi$ .



**Proof:** see Appendix A.3.

Indeed, that Firm 2's obfuscation and the share of naive consumers in equilibrium weakly decrease also applies to a discrete upward jump in  $\phi$ . To avoid discussing too many cases, we present this result in terms of a marginal change in  $\phi$ . When  $\tilde{\mu}(\phi)$  is attainable, an increase in asymmetry strictly reduces obfuscation and consequently the share of naive consumers. In a more asymmetric market, the less prominent Firm 2 receives less naive consumers and therefore, it prefers a lower share of naive consumers in the market also to enjoy its advantage in competing for sophisticated consumers. As a result, Firm 2 obfuscates less in a more asymmetric market.

A related question that arises is whether symmetric markets are more or less competitive than asymmetric markets. While asymmetric markets are less competitive for a given share of naive consumers (see Lemma 2), we identify an opposing effect if the number of naive consumers is endogenously determined via obfuscation. Asymmetry generally leads to less obfuscation and a lower number of naive consumers, which is a pro-competitive effect. The overall effect of asymmetry is hence ambiguous and depends on the strength of those two effects.

Consumer protection policy reduces the proportion of consumers who are susceptible to obfuscation. Clearly, a larger  $x$  shifts the interval  $[\underline{\mu}_x, \bar{\mu}_x]$  downwards. If Firm 2 obfuscates fully before and after a strengthening of consumer protection policy, the policy is effective and the share of naive consumers decreases. The same holds true if Firm 2 chooses not to obfuscate in both cases. Interestingly, a stricter policy may not be effective. If for a level of asymmetry  $\phi$  such that

$$\tilde{\mu}(\phi) \in [\underline{\mu}_{x'}, \bar{\mu}_{x'}] \cap [\underline{\mu}_{x''}, \bar{\mu}_{x''}] \neq \emptyset$$

where  $x'' > x'$ ,  $\tilde{\mu}(\phi)$  is attainable before and after the policy change. From Proposition 2, we see that the equilibrium share of naive consumers is unaffected by the policy change. The effect of a larger  $x$  is neutralized by an increase in obfuscation by Firm 2. Therefore, an introduction of a consumer protection policy can be ineffective in raising the share of sophisticated consumers in a market. Intuitively, for given obfuscation choices a stricter pol-

icy reduces the share of naive consumers. If this share falls short of the desired share of naive consumers Firm 2 reacts by increasing obfuscation. Firm 1 does not react to the policy change as obfuscation is already maximal.

**Proposition 4.** Suppose consumer protection policy strictly increases from  $x'$  to  $x''$ .

1. If  $\bar{\mu}_{x''} \geq \underline{\mu}_{x'}$  and  $\bar{\mu}_{x''} > \frac{1}{2}$ , then there exists a  $\phi$  such that  $\tilde{\mu}(\phi) \in [\underline{\mu}_{x'}, \bar{\mu}_{x''}]$ . Moreover, for all such  $\phi$ , the equilibrium share of naive consumers is not affected and Firm 2 obfuscates more.
2. The equilibrium share of naive consumers is reduced in the following three cases.
  - (a)  $\bar{\mu}_{x''} < \underline{\mu}_{x'}$ ;
  - (b)  $\bar{\mu}_{x''} \geq \underline{\mu}_{x'}$  but  $\bar{\mu}_{x''} \leq \frac{1}{2}$ ;
  - (c)  $\bar{\mu}_{x''} \geq \underline{\mu}_{x'}$  and  $\bar{\mu}_{x''} > \frac{1}{2}$ , but  $\tilde{\mu}(\phi) \notin [\underline{\mu}_{x'}, \bar{\mu}_{x''}]$ .

**Proof:** see Appendix A.4.

Proposition 4 shows that if the consumer protection policy does not become sufficiently effective, i.e.  $\bar{\mu}_{x''} \geq \underline{\mu}_{x'}$  and  $\bar{\mu}_{x''} > \frac{1}{2}$ , then there exist cases in which Firm 2's preferred level of naive consumers is attainable both before and after the policy change, and hence in these cases the equilibrium share of naive consumers remains unchanged despite of the policy change. Proposition 4 also shows that in all other cases, the policy change is effective in reducing equilibrium share of naive consumers.

In the example of Figure 2,  $[\underline{\mu}_x, \bar{\mu}_x]$  changes from  $[0.6, 0.9]$  to  $[0.55, 0.85]$  after  $x$  increased from  $x'$  to  $x''$ . Since they intersect and for  $\phi \in [\tilde{\mu}^{-1}(\bar{\mu}_{x''}), \tilde{\mu}^{-1}(\underline{\mu}_{x'})]$ ,  $\tilde{\mu}(\phi)$  is attainable before and after the policy change, this change in policy has no effect on the equilibrium share of naive consumers when  $\phi$  is in this interval.

It is indeed surprising to see that a more stringent consumer protection policy can be rendered completely ineffective by the actions of market participants. Considering the often substantial costs in implementing and enforcing such policies, more caution is needed in making such policies. It is

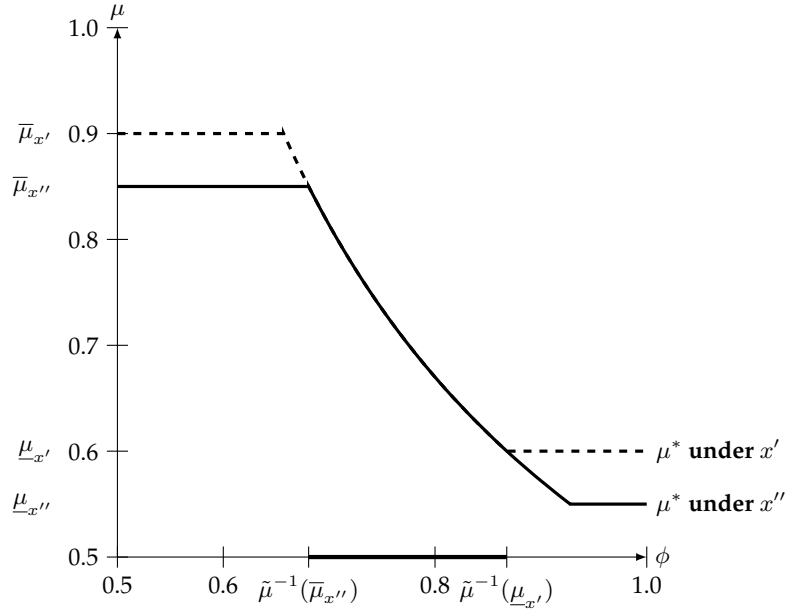


Figure 2: Equilibrium shares of naive consumers before ( $x'$ ) and after ( $x''$ ) an increase in consumer protection strength: for  $\phi \in [\tilde{\mu}^{-1}(\bar{\mu}_{x''}), \tilde{\mu}^{-1}(\underline{\mu}_{x'})]$ ,  $\mu^*$  remains the same

important to note that a policy change can have different impacts in symmetric and asymmetric industries. If firms are rather symmetric, both firms choose maximal obfuscation before and after the policy change and hence the policy is effective.<sup>18</sup> If, however, firms differ in their level of prominence the policy effect can be very different and the policy may be ineffective.

### 3 Extensions and modifications

In this part, we discuss whether our model can be extended regarding five aspects: alternative consumer protection policies, costs in obfuscation, price above the reservation value, the number of firms and the possibility of “reverse obfuscation”.

<sup>18</sup>In particular, if  $\phi \in \left(\frac{1}{2}, \frac{\sqrt{5}-1}{2}\right]$ , Firm 2 chooses maximal obfuscation independent of the level of consumer protection policy. In this case, policy is effective and reduces the share of naive consumers.

### 3.1 Firm-side consumer protection policies

There are other policies that act directly on firms. For instance, to protect consumers, a regulator may limit the length of the “footer” section of a credit card contract. One can model this type of policies through the highest possible obfuscation level under regulation,  $\bar{k}$ . Let  $\bar{k}'$  and  $\bar{k}''$  be the highest possible obfuscation levels before and after an increase in firm-side policy, respectively. That is, firm  $i$  chooses obfuscation  $k_i$  from  $[\underline{k}, \bar{k}']$  before the increase and from  $[\underline{k}, \bar{k}'']$  after the increase, where  $\bar{k}'' < \bar{k}'$ .

As in the consumer-side policy case, Firm 1 prefers as many naive consumers as possible, and always chooses maximum obfuscation. Therefore, for a given level of Firm 2’s obfuscation such a policy would be effective in reducing overall obfuscation and hence, the share of naive consumers. Also, as in the consumer-side policy case, however, when Firm 2’s most preferred share of naive consumers  $\tilde{\mu}(\phi)$  is attainable by choosing an intermediate level of obfuscation, Firm 2 might obfuscate more in response to a strengthening of the firm-side policy.

For a given consumer-side protection policy  $x$ , let  $\underline{\mu}_{\bar{k}'} = (1 - x)\theta(\bar{k}', \underline{k})$  and  $\bar{\mu}_{\bar{k}'} = (1 - x)\theta(\bar{k}', \bar{k}')$  be the lowest and the highest share of naive consumers that Firm 2 can attain under  $\bar{k}'$ . Likewise, let  $\underline{\mu}_{\bar{k}''} = (1 - x)\theta(\bar{k}'', \underline{k})$  and  $\bar{\mu}_{\bar{k}''} = (1 - x)\theta(\bar{k}'', \bar{k}'')$  be the lowest and the highest share of naive consumers that Firm 2 can attain under  $\bar{k}''$ . Analogous to Proposition 4, we have the following result for firm-side consumer protection policy.

**Proposition 5.** Let the consumer-side protection policy  $x \in (0, 1)$  be fixed. Suppose an increase in firm-side consumer protection policy reduces  $\bar{k}'$  to  $\bar{k}''$ .

1. Firm 1 obfuscates less.
2. If  $\bar{\mu}_{\bar{k}''} \geq \underline{\mu}_{\bar{k}'}$  and  $\bar{\mu}_{\bar{k}''} > \frac{1}{2}$ , then there exists a  $\phi$  such that  $\tilde{\mu}(\phi) \in [\underline{\mu}_{\bar{k}'}, \bar{\mu}_{\bar{k}''}]$ . Moreover, for all such  $\phi$ , the equilibrium share of naive consumers is not affected and Firm 2 obfuscates more.
3. The equilibrium share of naive consumers is reduced in the following three cases.

- (a)  $\bar{\mu}_{\bar{k}''} < \underline{\mu}_{\bar{k}'}$ ;
- (b)  $\bar{\mu}_{\bar{k}''} \geq \underline{\mu}_{\bar{k}'}$  but  $\bar{\mu}_{\bar{k}''} \leq \frac{1}{2}$ ;
- (c)  $\bar{\mu}_{\bar{k}''} \geq \underline{\mu}_{\bar{k}'}$  and  $\bar{\mu}_{\bar{k}''} > \frac{1}{2}$ , but  $\tilde{\mu}(\phi) \notin [\underline{\mu}_{\bar{k}'}, \bar{\mu}_{\bar{k}''}]$ .

The proof of Proposition 5, which is omitted here, follows closely that of Proposition 4 after noting that  $\bar{\mu}_{\bar{k}''} < \bar{\mu}_{\bar{k}'}$  and  $\underline{\mu}_{\bar{k}''} < \underline{\mu}_{\bar{k}'}$ . The intuition also carries over.

Similar to the consumer-side policy case, whether a firm-side policy is effective or not in reducing the equilibrium share of naive consumers depends largely on the extent it reduces the upper bound of the attainable share of naive consumers,  $\bar{\mu}_{\bar{k}''}$ . If  $\bar{\mu}_{\bar{k}''} < \max\{\underline{\mu}_{\bar{k}'}, \frac{1}{2}\}$ , the policy is guaranteed to be effective.

Sometimes both consumer-side and firm-side consumer protection measures are available to policy-makers and the question arises which policy should be implemented. In our model the effects of both policies are rather similar (compare Proposition 4 and 5) and it is clear that the effectiveness of policy measures rely heavily on the upper bound of the attainable share of naive consumers. Our model suggests that typically both types of policies are effective or none is.<sup>19</sup> Thus, whether a policy-maker should choose consumer-side, firm-side or a mix to implement the most effective policy measure depends largely on the function  $\mu(x, k_1, k_2)$  and the associated costs of the two types of policies.

### 3.2 Costly obfuscation

In this part we consider the implications of obfuscation costs. To isolate the effect of prominence, we assume  $\theta$  is symmetric. More specifically, we assume that the values of the twice continuously differentiable function  $\theta$

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<sup>19</sup>Suppose, for instance, if  $x$  is high, the interval  $[\underline{\mu}_x, \bar{\mu}_x]$  is rather low and Firm 2 is likely to obfuscate fully. In that case, both policy measures (reducing  $\bar{k}$  and increasing  $x$ ) are likely to be very effective. To the contrary, suppose that  $x$  is a bit lower so that Firm 2 chooses an intermediate level of obfuscation. In that case, neither policy measure can be (locally) effective. In response to either intervention, Firm 2 would react by obfuscating more making both policy measures potentially ineffective.

and its first and second order derivatives remain the same at each permutation of  $(k_1, k_2)$ . For simplicity, we consider a strictly positive but not prohibitively high constant marginal cost of obfuscation,  $c$ . To focus on non-trivial cases, let  $\frac{\partial \theta}{\partial k_i}(\underline{k}, \underline{k})$  be sufficiently large and  $\frac{\partial \theta}{\partial k_i}(\bar{k}, \bar{k}) = 0$ . In the benchmark zero cost case, the more prominent Firm 1 generally obfuscates more than the less prominent Firm 2. We now show that this result still holds when obfuscation is costly.

**Proposition 6.** Let  $\theta : [\underline{k}, \bar{k}]^2 \rightarrow (0, 1)$  be symmetric and twice continuously differentiable. Assume  $\frac{\partial \theta}{\partial k_i} > 0$ ,  $\frac{\partial^2 \theta}{\partial k_i^2} < 0$  and  $\frac{\partial^2 \theta}{\partial k_i^2} < \frac{\partial^2 \theta}{\partial k_1 \partial k_2} < -\frac{\partial^2 \theta}{\partial k_i^2}$  for  $i = 1, 2$ . Then, Firm 1's equilibrium obfuscation is always higher than that of Firm 2.

**Proof:** see Appendix A.5.

Proposition 6 confirms that the pattern of strategic obfuscation remains qualitatively unchanged when obfuscation is costly. The more prominent firm obfuscates more as long as the cross derivative of  $\theta$  is well behaved. The intuition of the standard case also carries over: the more prominent firm benefits more from the presence of naive consumers and it has stronger incentives to obfuscate.

We argue that an increase in consumer protection policy  $x$  in this case is expected to decrease Firm 1's obfuscation level. The reason is that under a stricter protection policy, the same level of obfuscation confuses fewer consumers and therefore the marginal benefit of obfuscation decreases. This prompts Firm 1 to reduce costly obfuscation. See the first order condition (20) in Appendix A.5.<sup>20</sup> The prediction for Firm 2 is less clear cut because it depends on how much the share of naive consumers has decreased as  $\mu$  appears in its first order condition (21). Depending on the functional form of  $\theta$ , Firm 2's equilibrium obfuscation may either decrease or increase. Thus the impact of consumer protection policy is qualitatively similar to the standard case where obfuscation is costless.

<sup>20</sup>Given that the cross derivative is only of second order importance.

### 3.3 Prices above the reservation value

So far, we have assumed that firms cannot choose prices above the reservation price  $r$ . But, in fact, firms might have incentive to raise the price above  $r$  if confused consumers—besides being unable to compare different offers—are also unable to evaluate whether the offer is worthwhile to buy at all. In this section we consider the implications when firms may charge prices up to  $\bar{r} > r$ .

Consumers paying prices higher than  $r$  receive a negative surplus. Hence, sophisticated consumers will never buy at such prices, but rather abstain from buying the product at all. Naive consumers, however, may buy at such prices as they do not understand the true price. As a result, a firm charging above  $r$  can only expect to sell to naive consumers. The following proposition characterizes the pricing stage:

**Lemma 3.** Define  $\mu_1 = \frac{r}{\bar{r}(1-\phi)+r\phi}$  and  $\mu_2 = \frac{r}{\bar{r}\phi+r(1-\phi)}$ , where  $\mu_1 > \mu_2$ .

1. Suppose  $\mu \geq \mu_1$ . Then, there exists a pure strategy equilibrium where both firms charge  $p_1 = p_2 = \bar{r}$ . Profits are  $\Pi_1 = \phi\mu\bar{r}$  and  $\Pi_2 = (1 - \phi)\mu\bar{r}$ .
2. Suppose  $\mu_1 > \mu \geq \mu_2$ . Then, there exists a pure strategy equilibrium where firms charge  $p_1 = \bar{r}$  and  $p_2 = r$ . Profits are  $\Pi_1 = \phi\mu\bar{r}$  and  $\Pi_2 = (1 - \phi\mu)r$ .
3. Suppose  $\mu < \mu_2$ . Then, there exists a mixed-strategy equilibrium in which Firm 1 prices according to the cumulative distribution function

$$F_1(p) = \begin{cases} 0 & \text{if } p < p_0 \\ \frac{(1-\phi\mu)[(\phi\mu+1-\mu)p-\phi\mu\bar{r}]}{(1-\mu)(\phi\mu+1-\mu)p} & \text{if } p_0 \leq p < r \\ 1 & \text{if } p = \bar{r} \end{cases} \quad (17)$$

and Firm 2 prices according to the cumulative distribution function

$$F_2(p) = \begin{cases} 0 & \text{if } p < p_0 \\ 1 - \frac{\phi\mu}{1-\mu} \left( \frac{\bar{r}}{p} - 1 \right) & \text{if } p_0 \leq p < r \\ 1 & \text{if } p \geq r, \end{cases} \quad (18)$$

where

$$p_0 := \frac{\phi\mu}{\phi\mu + 1 - \mu} \bar{r} \quad (19)$$

is the lower bound of both firms' prices. Firm 1 earns profits of  $E(\Pi_1) = \phi\mu\bar{r}$ . Firm 2 earns profits of  $E(\Pi_2) = \frac{(1-\phi\mu)\phi\mu\bar{r}}{\phi\mu+1-\mu}$ .

**Proof:** see Appendix A.6.

The equilibrium pricing strategy comes in three parts and depends largely on the number of naive consumers. For a large number of naive consumers ( $\mu \geq \mu_1$ ), there exists a pure-strategy equilibrium where both firms charge the highest possible price,  $\bar{r}$ . In this equilibrium, firms target only naive consumers who receive a negative surplus as the price exceeds the valuation of the product. Sophisticated consumers do not buy at this price. Note that both firms benefit from the presence of naive consumers and, hence, both firms' profits are increasing in  $\mu$ .

For an intermediate number of naive consumers ( $\mu_1 > \mu \geq \mu_2$ ), there exists a pure-strategy equilibrium with  $p_1 = \bar{r}$  and  $p_2 = r$ . As Firm 1 charges above the reservation value, it targets naive consumers only. Firm 2 sells to both consumer groups, to its share of naive consumers and to all sophisticated consumers. In this equilibrium, total consumer surplus is negative as all those consumers buying from Firm 1 obtain strictly negative utility while consumers buying from Firm 2 receive zero surplus. Firms have conflicting views on the number of naive consumers. Firm 1's (2's) profits are strictly increasing (decreasing) with  $\mu$ .

Finally, for a small number of naive consumers ( $\mu < \mu_2$ ), there exists an equilibrium in mixed strategies. This equilibrium resembles the mixed-strategy equilibrium from the base model and has similar properties. Both firms randomize about prices, and Firm 1 charges on average a higher price than Firm 2. Note, however, that the price distributions of both firms have mass points. Firm 1 has a mass point at  $\bar{r}$  and Firm 2 at  $r$ . Firm 1 profits are increasing in the share of naive consumers. Firm 2 profits are hump-shaped and may—as in the base model—increase or decrease in the share of naive consumers. The maximum is attained at the same level  $\tilde{\mu}$  as in the base model.



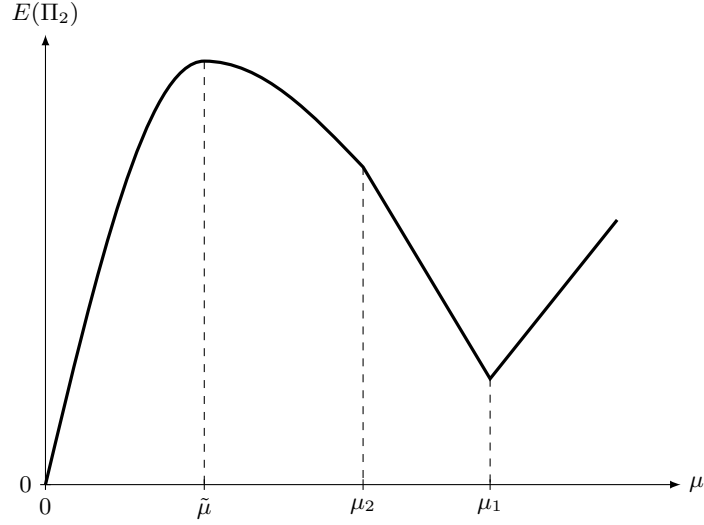


Figure 3: Firm 2 profits depending on the share of naive consumers ( $\mu$ )

Regarding obfuscation decisions in stage 1, for all pricing regimes, Firm 1's profits are strictly increasing in the number of naive consumers. Hence, Firm 1 chooses maximal obfuscation,  $k_1^* = \bar{k}$ . Firm 2's profits are non-monotonic, however, so the obfuscation choice is more involved. Figure 3 plots an example. As is evident from the figure, depending on  $[\underline{\mu}_x, \bar{\mu}_x]$ , Firm 2 may choose maximum, minimum or an intermediate level of obfuscation. For instance, if  $\tilde{\mu} \in [\underline{\mu}_x, \bar{\mu}_x]$ , intermediate obfuscation would result with  $k_2^*$  chosen such that  $\mu^* = \tilde{\mu}$ .

We now study the impact of protection policies. Depending on parameters we would have to consider and differentiate many cases. Hence, in the following we will focus our discussion on some key cases. We will show that, as in the base model, the introduction of a consumer protection policy may not be effective. We will also show that in the most harmful cases, where obfuscation might lead to negative consumer surplus, consumer protection policies are effective.

**Proposition 7.** Suppose consumer protection policy strictly increases from  $x'$  to  $x''$ .

1. If  $\tilde{\mu} \in [\underline{\mu}_{x'}, \bar{\mu}_{x'}]$  and  $\tilde{\mu} \in [\underline{\mu}_{x''}, \bar{\mu}_{x''}]$ , then the equilibrium share of naive

consumers is unaffected and Firm 2 obfuscates more.

2. If  $\mu^* > \mu_2$  results under policy  $x'$ , then the equilibrium share of naive consumers is reduced following the introduction of policy  $x''$ .

The first part shows that, as in the base model, a consumer protection policy might not be effective as it might increase the obfuscation incentives by Firm 2. The intuition from the base model carries over.

Like in the base model before, the second part of the proposition shows that in the most harmful cases, namely where obfuscation leads to negative consumer surplus, consumer protection is effective. In these cases, the number of naive consumers is reduced in response to the policy. The reason is that under  $x'$  Firm 2 chooses either minimum or maximum obfuscation, but not an intermediate level of obfuscation (see Figure 3). Both the minimum as well as the maximum level of naive consumers that are attainable under  $x''$  are reduced. Hence, the policy  $x''$  reduces the equilibrium share of naive consumers.

### 3.4 Number of firms

We now check the validity of our main result in oligopolies instead of a duopoly. Suppose there are  $N > 2$  firms in the market that differ in their prominence and let  $\phi_i$  be the share of naive consumers Firm  $i = 1, 2, \dots, N$  receives. Without loss of generality, assume  $\phi_i > \phi_{i+1}$  for all  $i$ . Drawing from Kocas and Kiyak (2006), we know that for a given share of naive consumers  $\mu \in (0, 1)$ , Firms 1 to  $N - 2$  charge the reservation price  $r$  while Firms  $N - 1$  and  $N$  will compete for the sophisticated consumers in the pricing equilibrium. In other words, only the two least prominent firms employ mixed strategy pricing. Accordingly, all firms except for Firm  $N$  earn the same expected profits as they would earn by selling only to their own shares of naive consumers. That is,  $E(\Pi_i) = \phi_i \mu r$ ,  $i = 1, 2, \dots, N - 1$ . For the same reasons explained before, Firm  $N$  earns higher expected profits than selling only to its own share of naive consumers,  $E(\Pi_N) = \frac{\phi_{N-1} \mu r [\phi_N \mu + 1 - \mu]}{\phi_{N-1} \mu + 1 - \mu} > \phi_N \mu r$ .<sup>21</sup>

<sup>21</sup>The derivations are available from the authors but omitted here for brevity.

In the obfuscation stage, all firms except for Firm  $N$  prefer maximal obfuscation while Firm  $N$ , like Firm 2 in the standard case, has its ideal level of naive consumers,  $\tilde{\mu}$ . Hence, a result that resembles Proposition 1 can be established where Firms 1 to  $N - 1$  obfuscate fully and Firm  $N$ 's choice of obfuscation depends on the comparison between  $\tilde{\mu}$  and the attainable range of  $\mu$  for Firm  $N$ . As a result, if  $\tilde{\mu}$  is attainable before and after a strengthening in consumer protection policy, Firm  $N$  will obfuscate more and the policy will be rendered ineffective. In this sense, our main result holds qualitatively in a general oligopoly.

### 3.5 Counter obfuscation

Although in our model firms are allowed only to obfuscate, practices in the opposite direction can easily be taken into account. This is because instead of "no obfuscation",  $\underline{k}$  can also be interpreted as, for example, offering a verifiable price comparison which arguably reduces the share of naive consumers. As it is clear that only Firm 2 may prefer a lower  $k$  in equilibrium, this extension just amounts to allowing for a lower  $\underline{\mu}_x$ . Consequently, *ceteris paribus*, Case (2b) in Proposition 1 becomes more likely while Case (2c) less likely.

## 4 Conclusion

In this paper we have studied obfuscation incentives by firms. Competing firms are heterogeneous in their level of prominence. While prominent firms always choose to obfuscate, the incentives to obfuscate for less prominent firms are more differentiated. We have identified several factors that determine the optimal level of obfuscation. A lower level of asymmetry in prominence and a stricter consumer protection policy increase the less prominent firms' incentives to obfuscate.

The key aim of the paper is to study the impact of regulation. We have shown that consumer protection policies designed to reduce the scope of obfuscation can have unintended consequence in asymmetric industries. While the effect on prominent firms is as expected, there is an unintended,

adverse effect on less prominent firms. We have shown that these firms may actually react by increasing their obfuscation levels due to such a policy. In the working paper version of our paper, Gu and Wenzel (2012), we provide experimental evidence which suggests that consumer protection policies are indeed less effective than expected. However, more empirical evidence is needed here. An interesting avenue for future research would be to test this prediction using field data, possibly making use of the various policy reforms in financial markets that have occurred in recent years.

Our analysis yields several implications for policy decision making. First, we show that more prominent firms are more likely to obfuscate than less prominent ones. Consequently policy makers, aiming at promoting market transparency, should design policies that target those firms. This is particularly effective in markets where asymmetry is large. Second, policy makers should be aware that consumer protection policies that promote transparency may backfire in the sense that it may increase the incentives of less prominent firms to engage in obfuscation strategies. We show that under certain circumstances this may leave the level of transparency in the market unchanged and thus make the policy redundant.

## A Appendix

### A.1 Comparative statics of price equilibrium

We show that expected prices charged by both firms increase in  $\mu$ . This can be demonstrated by showing that the equilibrium distribution functions decrease in  $\mu$ .

1.  $\frac{dF_2}{d\mu} = -\frac{\phi(r-p)}{(1-\mu)^2 p}$ . This is negative for all  $p < r$  and equal to zero for  $p = r$ . Hence, the expected price charged by Firm 2 increases with  $\mu$ .
2.  $\frac{dF_1}{d\mu} = \frac{p(1-\phi)(\phi\mu+1-\mu)^2 + \phi r(2\phi\mu-1-3\phi\mu^2+\mu^2-\phi^2\mu^2)}{(1-\mu)^2(\phi\mu+1-\mu)^2 p}$ . To show that  $\frac{dF_2}{d\mu} < 0$ , it suffices to show that the numerator is negative. Define  $h = p(1-\phi)(\phi\mu+1-\mu)^2 + \phi r(2\phi\mu-1-3\phi\mu^2+\mu^2-\phi^2\mu^2)$ . Note that  $\frac{dh}{dp} = (1-\phi)(\phi\mu+1-\mu)^2 > 0$  and  $h(p=r) = -r(1-\mu)^2(2\phi-1) < 0$ . Hence,  $h < 0$  for all  $p \leq r$ . Therefore,  $\frac{dF_2}{d\mu} < 0$ .

## A.2 Proof of Proposition 1

**Proof:** We only show Firm 2's optimal obfuscation. Firm 2 wants to increase or decrease its own obfuscation level if

$$\frac{\partial E(\Pi_2)}{\partial k_2} \geq 0 \Leftrightarrow \phi(1 - \phi)\mu^2 - 2\phi\mu + 1 \geq 0.$$

Let  $\omega(\mu) := \phi(1 - \phi)\mu^2 - 2\phi\mu + 1$ .  $\omega(\mu)$  is a parabola that opens upward with two roots being  $\frac{\phi \pm \sqrt{\phi(2\phi-1)}}{\phi(1-\phi)}$ . Since the larger root is above 1,  $\tilde{\mu}(\phi)$  is the root of interest.

We note that  $\mu(x, k_1, k_2)$  strictly increases in  $k_2$ . We further differentiate three cases. First, if  $\bar{\mu}_x < \tilde{\mu}(\phi)$ ,  $\omega(\mu) > 0$  for all  $\mu \in [\underline{\mu}_x, \bar{\mu}_x)$  and therefore, Firm 2 wants to increase its obfuscation level to the upper bound,  $\bar{k}$ . Second, if  $\underline{\mu}_x > \tilde{\mu}(\phi)$ ,  $\omega(\mu) < 0$  for all  $\mu \in [\underline{\mu}_x, \bar{\mu}_x]$  as  $\bar{\mu}_x < 1 < \frac{\phi + \sqrt{\phi(2\phi-1)}}{\phi(1-\phi)}$ . Consequently, Firm 2 wants to reduce its obfuscation level to the lower bound,  $\underline{k}$ . Finally, when  $\underline{\mu}_x < \tilde{\mu}(\phi) < \bar{\mu}_x$ ,  $\omega(\mu) > 0$  for all  $\mu \in [\underline{\mu}_x, \tilde{\mu}(\phi))$  and  $\omega(\mu) < 0$  for all  $\mu \in (\tilde{\mu}(\phi), \bar{\mu}_x]$ . The best choice for Firm 2 is then the unique level of obfuscation such that  $\mu(x, k_1, k_2) = \tilde{\mu}(\phi) = (1 - x)\theta(\bar{k}, k_2)$ . The boundary cases are easily checked. Q.E.D.

## A.3 Proof of Proposition 3

**Proof:** Following Propositions 1 and 2, we only have to show Part 2.

If  $\underline{\mu}_x < \tilde{\mu}(\phi) < \bar{\mu}_x$ ,  $\mu^* = \tilde{\mu}(\phi)$  and consequently,  $\mu^*$  strictly decreases in  $\phi$ . See Equation (16).

From Proposition 1, we know in this case  $(1 - x)\theta(\bar{k}, k_2^*) = \tilde{\mu}(\phi)$ . Differentiating both sides w.r.t.  $\phi$  we have

$$(1 - x) \frac{\partial \theta}{\partial k_2} \frac{dk_2^*}{d\phi} = \frac{d\tilde{\mu}(\phi)}{d\phi} < 0.$$

Hence, whenever  $\mu^* = \tilde{\mu}(\phi)$ ,  $\frac{dk_2^*}{d\phi} < 0$ , that is, Firm 2's equilibrium obfuscation strictly decreases in  $\phi$ .

Q.E.D.

#### A.4 Proof of Proposition 4

**Proof:** Since  $x'' > x'$ , we note that  $\bar{\mu}_{x''} < \bar{\mu}_{x'}$  and  $\underline{\mu}_{x''} < \underline{\mu}_{x'}$ .

1. Suppose  $\bar{\mu}_{x''} \geq \underline{\mu}_{x'}$  and  $\bar{\mu}_{x''} > \frac{1}{2}$ . Since  $\tilde{\mu}(\phi)$  is a continuous and strictly decreasing function with domain  $(\frac{1}{2}, 1)$  and range  $(\frac{1}{2}, 2)$ , there exists a  $\phi$  such that  $\tilde{\mu}(\phi) \in [\underline{\mu}_{x'}, \bar{\mu}_{x''}]$ . This means that for all such  $\phi$ ,  $\tilde{\mu}(\phi)$  is attainable before and after the policy change. By Proposition 2,  $\mu^*$  remains the same. As  $(1-x')\theta(\bar{k}, k_2^*) = (1-x'')\theta(\bar{k}, k_2^{*'})$ ,  $x'' > x'$  and  $\frac{\partial \theta}{\partial k_2} > 0$ ,  $k_2^{*' > k_2^*$ . Therefore, in this case Firm 2 obfuscates more.
2. We now consider the following three cases. In each case, we show that the equilibrium share of naive consumers is lower under  $x''$  than under  $x'$ .
  - (a) If  $\bar{\mu}_{x''} < \underline{\mu}_{x'}$ ,  $[\underline{\mu}_{x''}, \bar{\mu}_{x''}]$  and  $[\underline{\mu}_{x'}, \bar{\mu}_{x'}]$  do not intersect. The equilibrium share of naive consumers is trivially reduced.
  - (b) Suppose  $\bar{\mu}_{x''} \geq \underline{\mu}_{x'}$  but  $\bar{\mu}_{x''} \leq \frac{1}{2}$ . In this case  $\bar{\mu}_{x''} \leq \frac{1}{2} < \tilde{\mu}(\phi)$  for all  $\phi \in (\frac{1}{2}, 1)$ . By Proposition 1, the equilibrium share of naive consumers after the policy change is  $\bar{\mu}_{x''}$  which is strictly less than either  $\bar{\mu}_{x'}$  (if  $\bar{\mu}_{x'} \leq \frac{1}{2}$ ) or any previously attainable  $\tilde{\mu}(\phi)$  (if  $\bar{\mu}_{x'} > \frac{1}{2} > \underline{\mu}_{x'}$ ).
  - (c) Suppose  $\bar{\mu}_{x''} \geq \underline{\mu}_{x'}$  and  $\bar{\mu}_{x''} > \frac{1}{2}$  but  $\tilde{\mu}(\phi) \notin [\underline{\mu}_{x'}, \bar{\mu}_{x''}]$ . By Proposition 1, for those  $\phi$  such that  $\tilde{\mu}(\phi) > \bar{\mu}_{x''}$ , the equilibrium share of naive consumers under  $x'$  is either  $\bar{\mu}_{x'}$  or  $\tilde{\mu}(\phi)$ . Both are larger than the equilibrium share of naive consumers under  $x''$ ,  $\bar{\mu}_{x''}$ . When there exist a  $\phi$  such that  $\tilde{\mu}(\phi) < \underline{\mu}_{x'}$ , the equilibrium share of naive consumers under  $x'$  is  $\underline{\mu}_{x'}$ . For all such  $\phi$ , the equilibrium share of naive consumers is reduced under  $x''$  because it is either  $\tilde{\mu}(\phi)$  or  $\underline{\mu}_{x'}$ .

*Q.E.D.*

#### A.5 Proof of Proposition 6

**Proof:** We differentiate two cases. First, as in the zero cost case, when

$$\phi(1-\phi)\mu^2 - 2\phi\mu + 1 \leq 0,$$

$\frac{\partial E(\Pi_2)}{\partial k_2} \leq 0$  and hence, Firm 2 chooses not to obfuscate. Second, when  $\phi(1 - \phi)\mu^2 - 2\phi\mu + 1 > 0$  we have an interior solution as  $\frac{\partial \theta}{\partial k_i}(\underline{k}, \underline{k})$  is assumed to be sufficiently large and  $\theta$  is twice continuously differentiable. We show in both cases, Firm 1 obfuscates more in equilibrium.

The first case is trivial. Suppose  $\phi(1 - \phi)\mu^2 - 2\phi\mu + 1 \leq 0$  and hence  $k_2^* = \underline{k}$ . Since  $\frac{\partial \theta}{\partial k_1}(\underline{k}, \underline{k})$  is sufficiently large,  $c < \phi r(1 - x)\frac{\partial \theta}{\partial k_1}(\underline{k}, \underline{k})$ , and this means  $k_1^* > \underline{k} = k_2^*$ .

We now consider equilibria in which  $k_i^* > \underline{k}$  for  $i = 1, 2$ . At such an interior solution the first order conditions are met. Using (13) and (14) and taking into account the constant marginal cost of obfuscation, we have

$$\frac{\partial E(\Pi_1)}{\partial k_1} - c = \phi r(1 - x)\frac{\partial \theta}{\partial k_1}(k_1^*, k_2^*) - c = 0 \quad (20)$$

$$\frac{\partial E(\Pi_2)}{\partial k_2} - c = \frac{[\phi(1 - \phi)\mu^2 - 2\phi\mu + 1]\phi r(1 - x)}{[\phi\mu + (1 - \mu)]^2} \frac{\partial \theta}{\partial k_2}(k_1^*, k_2^*) - c = 0. \quad (21)$$

From (20) and (21) we know

$$\frac{\partial \theta}{\partial k_1}(k_1^*, k_2^*) = \frac{[\phi(1 - \phi)\mu^2 - 2\phi\mu + 1]}{[\phi\mu + (1 - \mu)]^2} \frac{\partial \theta}{\partial k_2}(k_1^*, k_2^*).$$

Observe that

$$\begin{aligned} \phi(1 - \phi)\mu^2 - 2\phi\mu + 1 &< [\phi\mu + (1 - \mu)]^2 \\ \Leftrightarrow 2\phi^2\mu - 3\phi\mu + 4\phi + \mu - 2 &> 0 \\ \Leftrightarrow (2\phi - 1)[2 - (1 - \phi)\mu] &> 0. \end{aligned}$$

As  $\phi \in (\frac{1}{2}, 1)$  and  $\mu \in (0, 1)$ , we can conclude that

$$\frac{\partial \theta}{\partial k_1}(k_1^*, k_2^*) < \frac{\partial \theta}{\partial k_2}(k_1^*, k_2^*). \quad (22)$$

Our last step is to show that (22) implies  $k_1^* > k_2^*$ . By applying symmetry (twice) and Clairaut's theorem as  $\theta$  is twice continuously differentiable, we

have

$$\begin{aligned}
& \frac{\partial \theta}{\partial k_1}(k_1^*, k_2^*) - \frac{\partial \theta}{\partial k_2}(k_1^*, k_2^*) < 0 \Leftrightarrow \frac{\partial \theta}{\partial k_2}(k_2^*, k_1^*) - \frac{\partial \theta}{\partial k_2}(k_1^*, k_2^*) < 0 \\
& \Leftrightarrow \frac{\partial \theta}{\partial k_2}(k_1^*, k_1^*) - \int_{k_2^*}^{k_1^*} \frac{\partial^2 \theta}{\partial k_2 \partial k_1}(k, k_1^*) dk - \frac{\partial \theta}{\partial k_2}(k_1^*, k_1^*) + \int_{k_2^*}^{k_1^*} \frac{\partial^2 \theta}{\partial k_2^2}(k_1^*, k) dk < 0 \\
& \Leftrightarrow \int_{k_2^*}^{k_1^*} \left[ \frac{\partial^2 \theta}{\partial k_2^2}(k_1^*, k) - \frac{\partial^2 \theta}{\partial k_2 \partial k_1}(k, k_1^*) \right] dk < 0 \\
& \Leftrightarrow \int_{k_2^*}^{k_1^*} \left[ \frac{\partial^2 \theta}{\partial k_1^2}(k, k_1^*) - \frac{\partial^2 \theta}{\partial k_1 \partial k_2}(k, k_1^*) \right] dk < 0. \tag{23}
\end{aligned}$$

Since  $\frac{\partial^2 \theta}{\partial k_i^2} < \frac{\partial^2 \theta}{\partial k_1 \partial k_2}$ , (23) implies  $k_1^* > k_2^*$ . Q.E.D.

### A.6 Proof of Lemma 3

**Proof:** Define  $\mu_1 = \frac{r}{\bar{r}(1-\phi)+r\phi}$  and  $\mu_2 = \frac{r}{\bar{r}\phi+r(1-\phi)}$ , where  $\mu_1 > \mu_2$ .

1. Suppose that  $\mu \geq \mu_1$ . We show that both firms charging  $\bar{r}$  is an equilibrium. At this price firms only sell to naive consumers and earn profits of  $\Pi_1 = \phi\mu\bar{r}$  and  $\Pi_2 = (1-\phi)\mu\bar{r}$ . Note that charging a price  $p_i \in (r, \bar{r})$  is never optimal as at such prices only naive consumers buy and for a firm targeting naive consumers only charging  $\bar{r}$  is profit-maximising. A firm considering to deviate and sell also to sophisticated consumers has to reduce its price to  $r$ . This is not profitable for Firm 2 if  $(1-\phi)\mu\bar{r} \geq [(1-\phi)\mu + (1-\mu)]r \Leftrightarrow \mu \geq \frac{r}{\bar{r}(1-\phi)+r\phi} = \mu_1$ . Such a deviation is not profitable for Firm 1  $\phi\mu\bar{r} \geq [\phi\mu + (1-\mu)]r \Leftrightarrow \mu \geq \frac{r}{\bar{r}\phi+r(1-\phi)} = \mu_2$ . As  $\mu \geq \mu_1$ , no firm has incentive to deviate from  $p_1 = p_2 = \bar{r}$ .
2. Suppose  $\mu_1 > \mu \geq \mu_2$ . We show that  $p_1 = \bar{r}$  and  $p_2 = r$  is an equilibrium. Firm 1 sells to naive consumers only and Firm 2 sells to its share of naive consumers and to all sophisticated consumers. Firm 1 may consider to compete also for sophisticated consumers for which it needs to undercut the price by Firm 2. This is not profitable as  $\phi\mu\bar{r} \geq [\phi\mu + (1-\mu)]r \Leftrightarrow \mu \geq \frac{r}{\bar{r}\phi+r(1-\phi)} = \mu_2$ . Given that Firm 1 charges  $\bar{r}$  it is optimal to charge sophisticated consumers the highest possible price,  $r$ . Selling only to naive consumers does not lead to higher profits as  $(1-\phi)\mu\bar{r} < [(1-\phi)\mu + (1-\mu)]r \Leftrightarrow \mu < \frac{r}{\bar{r}(1-\phi)+r\phi} = \mu_1$ .



3. Suppose  $\mu < \mu_2$ . Then, both firms want to compete for sophisticated consumers and a pure strategy equilibrium does not exist. The existence of a mixed-strategy equilibrium can be shown along the lines of Varian (1980) and Narasimhan (1988), with two differences. First, both firms equilibrium price distributions have mass points; Firm 1's equilibrium distribution has a mass point on  $\bar{r}$  and Firms 2's on  $r$ . Second, in equilibrium, there is no density mass on prices in the interval  $(r, \bar{r})$ .

We start by deriving equilibrium profits. Firm 1 can always guarantee profits of  $E(\Pi_1) = \phi\mu\bar{r}$  by selling to naive consumers only. Firm 1 will also never set a lower price than  $p_0 = \frac{\phi\mu}{\phi\mu+(1-\mu)}\bar{r}$  as this would lead to lower profits even if selling to all sophisticated consumers. Hence, Firm 2 profits can be calculated as  $E(\Pi_2) = [(1-\phi)\mu + (1-\mu)]p_0 = \frac{(1-\phi\mu)\phi\mu\bar{r}}{\phi\mu+(1-\mu)}$ .

Next, we derive the equilibrium distribution functions. In equilibrium, firms randomize over prices in the interval  $[p_0, r]$  and there may be mass points at  $r$  and  $\bar{r}$ . Note that firms do not put positive density on prices in the interval  $(r, \bar{r})$  as those prices are strictly dominated by choosing  $\bar{r}$  instead. This is because at prices higher than  $r$  only naive consumer buy and those consumers buy in fixed proportions  $\phi : (1-\phi)$  from the two firms and, hence, do not react to price differences between firms.

Using the fact that in a mixed strategy equilibrium, every price in the domain of the mixed-strategy equilibrium must yield identical profits we can now solve for the equilibrium distribution functions. The equilibrium probability distribution function by Firm 2 is implicitly given by

$$\phi\mu\bar{r} = p[\phi\mu + (1-\mu)(1-F_2)],$$

which yields

$$F_2 = 1 - \frac{\phi\mu}{1-\mu} \left( \frac{\bar{r}}{p} - 1 \right). \quad (24)$$

Similarly, the equilibrium distribution function by Firm 1 is implicitly

given by

$$\frac{(1 - \phi\mu)\phi\mu\bar{r}}{\phi\mu + (1 - \mu)} = p[(1 - \phi)\mu + (1 - \mu)(1 - F_1)],$$

which gives

$$F_1 = \frac{(1 - \phi\mu)[(\phi\mu + 1 - \mu)p - \phi\mu\bar{r}]}{(1 - \mu)[\phi\mu + (1 - \mu)]p}. \quad (25)$$

Note that  $F_1(p = p_0) = F_2(p = p_0) = 0$ . Hence, both firms do not put density on prices below  $p_0$ . Note also that Firm 1's equilibrium strategy has a mass point on  $\bar{r}$ . The size of the mass point is  $1 - F_1(p = r) > 0$ . Firm 2 has a mass point on  $r$  with size  $1 - F_2(p = r) = \frac{\phi\mu(\frac{r}{\bar{r}} - 1)}{1 - \mu} > 0$ . Finally, we note that Firm 2 has no incentive to put positive density on  $\bar{r}$  as this would yield lower profits:  $E(\Pi_2) = \frac{(1 - \phi\mu)\phi\mu\bar{r}}{\phi\mu + (1 - \mu)} > (1 - \phi)\mu\bar{r} \Leftrightarrow \frac{(2\phi - 1)(1 - \mu)\mu\bar{r}}{\phi\mu + (1 - \mu)} > 0$ .

*Q.E.D.*

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