Competitive Markets, Add-On Prices, and Bounded Rationality*

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Abstract

We analyze the trade of differentiated products with potentially hidden add-on prices. Boundedly rational consumers mistakenly believe that product choice has no effect on the probability of incurring hidden add-on charges. However, all consumers correctly anticipate their equilibrium expenses, so there are no "surprise charges." Shrouding equilibria with inefficient trade exist, but only if the market is sufficiently competitive. There is an optimal maximal add-on price that defines the scope for profitable exploitative innovation. Further, product and exploitative innovation are complements, and the presence of boundedly rational consumers can generate innovation incentives that improve welfare relative to the rational benchmark.

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1 Introduction

Many products are offered with pricing schedules that comprise both base prices and add-on charges for additional services. Classic examples are credit or debit cards, mobile-phone services, actively managed mutual funds, as well as consumer products that require regular maintenance or updates such as cars, printers, and software. The add-on charges are often large relative to the base prices. In some markets, firms earn substantial economic profits from selling additional services at high add-on prices even when the industry is fairly competitive. From an industrial organization perspective, this phenomenon is not easy to rationalize as competition should drive down the sum of base and add-on prices and hence firms' profits.

To provide an explanation, Verboven (1999) and Ellison (2005) consider settings where firms can advertise base, but not add-on prices. A justification for the latter assumption is that it is costly (or impossible) for consumers to work through the fine-print of contracts to identify add-on fees. An equilibrium then exists where firms earn economic profits from charging high add-on prices despite competition. However, the assumption that prices cannot be advertised is difficult to justify as it should be feasible for firms to make their pricing schedules transparent to consumers. If firms are free to advertise their prices and all consumers are rational, then shrouding add-on prices cannot be a profitable strategy since consumers will always expect the worst possible outcome (e.g., the highest possible add-on price) for a hidden attribute. In a competitive market, this creates incentives for firms to make their pricing schedules transparent so that there is no scope for large, hidden add-on prices.

In order to resolve this puzzle, Gabaix and Laibson (2006) (henceforth GL06) formalize the idea that some consumers are "myopic" (or "naive"). These consumers do not take add-on prices into account as long as they are not explicitly advertised. Thus, they do not share the pessimism of rational consumers regarding prices that are hidden in fine print. GL06 show that, if the share of myopic consumers is sufficiently large, competition between firms is not enough to make prices transparent as educating myopic consumers about add-on charges would make them unprofitable for firms. Heidhues et al. (2017) (henceforth HKM17) expand on this mechanism and show that the presence of myopic consumers may induce firms to sell "deceptive" inferior products, which would reduce welfare. Thus, the existence of large, hidden add-on prices in competitive markets can be explained by myopic consumer beliefs. They imply that there is a case for public policy (e.g., consumer education or disclosure requirements).

The myopic consumer argument is, however, not entirely convincing in some markets. Credit and debit cards are "high-frequency products" (Gathergood et al., 2021) that provide quick feedback to consumers. Credit card fees are made salient on credit card statements. Overcharge fees for debit card transactions are also communicated quickly to consumers.

Since consumers have to manage their finances continuously, it does not seem plausible that a large fraction of them remains unaware about interest charges and penalty fees for a long time. Further, it may also not be in the best interest of firms to surprise consumers with unexpected add-on charges (Chiles, 2021). Selling investment products like actively managed funds – which often charge large management fees – requires consumer trust (Gennaioli et al., 2015). Consumers follow the asset managers whom they trust (Kostovetsky, 2016) and a reduction in trust reduces investments in equity (Gurun et al., 2018, Choi and Robertson, 2020). Thus, the sellers of investment products are concerned with reputation and may not be interested in disappointing their customers by charging surprise add-on fees.

In this paper, we provide an explanation for large, hidden add-on prices in competitive markets when firms are free to advertise all prices *and* all consumers correctly anticipate their equilibrium expenses. To obtain this result, we assume that some consumers have boundedly rational equilibrium beliefs: They know whether the product they purchase in equilibrium exhibits a hidden add-on charge, but they do not fully understand how their expenses would change if they purchased another product. In particular, they may not be able to identify products that do not charge hidden add-on prices. Since all consumers correctly anticipate their equilibrium expenses, there are no "surprise charges" on the equilibrium path. The model generates new results on the role of competition in markets with large, hidden add-on prices. It provides a natural prediction for the size of these prices. Further, it offers a new perspective on innovation incentives in such markets.

To discipline our approach, we build on the multi-product version of HKM17 and combine it with a version of the personal equilibrium concept from Spiegler (2016).[1] Firms sell a superior and an inferior product. Both products generate positive gains from trade (defined as consumer utility minus marginal cost), but the superior product yields greater gains than the inferior one. The inferior product may come with an add-on price that consumers cannot avoid. Firms choose whether to advertise their add-on prices or not. There are rational and boundedly rational consumers. The latter ones become rational when at least one firm advertises its add-on price. To allow for competition effects, we assume that products are horizontally differentiated. The only significant change we make relative to HKM17 is the boundedly rational consumers' belief formation process: They estimate the probability of positive add-on charges using data generated by their equilibrium actions. This change generates three new results.

First, we find that an equilibrium exists in which rational consumers purchase the superior product at the competitive price, while boundedly rational consumers buy the inferior product at the maximal add-on price. However, this equilibrium only exists as long as the maximal add-on price is not too large and the market is sufficiently competitive. If the maximal add-on

[1]In an extension, we also consider the model of Gabaix and Laibson (2006).

price were too large, boundedly rational consumers would stop purchasing it in order to avoid exploitation. If competition were too relaxed, firms would want to maximize the gains from trade and hence stop trading the inferior product. Crucially, both restrictions are due to the fact that all consumers correctly anticipate their equilibrium expenses. If the boundedly rational consumers in our model were myopic, the size of the maximal add-on price would not affect their behavior and a monopolist would happily exploit them to earn profits beyond the rational monopoly level. Overall, we find that large, hidden add-on prices can be explained without the assumption of myopic consumers. Thus, they can be consistent with high-frequency products and reputational concerns.

Second, the model generates a natural prediction for the maximal add-on price. We characterize the "optimal add-on price", i.e., the maximal add-on price that maximizes the sum of firms' profits. It equals the price firms would choose in a monopoly with rational consumers if only the inferior product were available. If the maximal add-on price exceeds its optimal level, then, in equilibrium, boundedly rational consumers do not purchase an inferior product with hidden add-on price in order to avoid exploitation. Related to this, if the inferior product does not offer any gains from trade, it cannot be sold profitably to consumers in equilibrium.

Third, we obtain new results on firms' innovation incentives. Heidhues et al. (2016) (henceforth HKM16) show that, in a shrouding equilibrium with non-appropriable innovation (firms can freely copy others' findings), firms always have incentives to invest into exploitative innovation that increases the maximal add-on price, but no incentives to invest into product innovation which increases the utility of the product that myopic consumers purchase. This finding changes with boundedly rational equilibrium beliefs. The incentives for exploitative innovation are bounded since firms would not push the maximal add-on price above its optimal level. Further, exploitative innovation and product innovation are complements in our setting: If firms can keep the maximal add-on price at the optimal level through continuous exploitative innovation, they directly benefit from product innovations that increase the value of the inferior product to consumers. Thus, the presence of boundedly rational consumers can have the same effect as patent protection for the inferior product. Finally, product innovation incentives are not limited to the elimination of welfare losses from inefficient trade. We show that the shrouding equilibrium survives even when the welfare ranking of the two products is reversed, provided that the gains from trade are not too different. Therefore, the presence of boundedly rational consumers can generate market power and hence innovation incentives that eventually improve welfare relative to the rational consumer benchmark.

The paper contributes to the behavioral industrial organization literature that studies how trade between firms and consumers is affected when some consumers are myopic or naive; see, e.g., DellaVigna and Malmendier (2004), Eliaz and Spiegler (2006), Grubb (2009, 2015), Miao (2010), Armstrong and Vickers (2012), Inderst and Ottaviani (2012), Shulman and Geng (2013), Warren and Wood (2014), Murooka (2015), Heidhues and Kőszegi (2017), Kosfeld and Schüwer (2017), Johnen (2020a,b), Hefti et al. (2022), Inderst and Obradovits (2023), and Ispano and Schwardmann (2023). By replacing myopic through boundedly rational equilibrium beliefs, we avoid the conflict between consumer expectations and experiences.

The link between competition and shrouding of add-on prices is new in the hidden add-on pricing literature. A similar finding has been established in the literature on price obfuscation, see Spiegler (2006), Carlin (2009), Piccione and Spiegler (2012), Chioveanu and Zhou (2013), and Chioveanu (2020). The difference between models of price obfuscation and hidden add-on pricing models is that, in the former type of models, firms can increase the share of boundedly rational consumers by adopting non-transparent pricing schedules. A typical finding in these models is that the degree of price obfuscation increases in the number of firms (as it is less profitable to compete for rational consumers when there are more firms). Importantly, to obtain this result, it is assumed that firms cannot charge prices above the consumers' valuation for the product. This ensures that random purchase decisions are weakly optimal for confused consumers. Our approach allows to avoid such an assumption while still obtaining a link between competition and obfuscation.

On a more general level, the paper contributes to the literature that examines markets where consumers face difficulties to evaluate the firms' offers due to search costs (Diamond, 1971), rational inattention (Matějka and McKay, 2012), or limited attention (De Clippel et al., 2014, Heidhues et al., 2021); and to the literature that studies markets with switching costs that are due to consumer inertia – created by psychological mechanisms such as status-quo bias (Samuelson and Zeckhauser, 1988) or the endowment effect (Kahneman et al., 1990) – or due to self-control problems (Andre et al., 2026) or loss aversion (Karle et al., 2023). These models show that informational and behavioral frictions can increase prices for consumers, but they do not explain why competition does not reduce these frictions. To study which mechanisms keep competitive markets away from being efficient, we assume that each firm has the option to costlessly remove any informational or behavioral friction on the side of consumers: If a firm wants to cut its rivals' prices and to communicate this effectively to consumers, it can do so at zero costs. We show that firms will not choose this option if the market is sufficiently competitive and even if all consumers correctly anticipate their equilibrium expenses.

To model boundedly rational beliefs, we use a personal equilibrium concept that captures coarse reasoning. It is a short-cut version of the Bayesian network framework from Spiegler (2016), where the decision-maker applies a misspecified causal model to make sense out of the data that she obtains in equilibrium. Notions of coarse or analogy-based reasoning in strategic settings have been developed in several papers, see, e.g., Eyster and Rabin (2005) and Jehiel (2005). Previous applications include adverse selection (Esponda, 2008, Murooka and Yamashita, 2025), learning in games (Mengel, 2012), investment decisions (Jehiel, 2018), strategic information transmission (Hagenbach and Koessler, 2020), as well as incentive contracts (Schumacher and Thysen, 2022); see Jehiel (2022) for a comprehensive survey. In parallel work, Antler and Spiegler (2025) study the competitive market equilibrium with state-dependent hidden add-on prices and consumers with boundedly rational equilibrium beliefs. The present paper applies a form of coarse reasoning to study markets with strategic firms and (potentially) hidden add-on prices.

The rest of the paper is organized as follows. In Section 2, we introduce our baseline model. In Section 3, we analyze under what circumstances there exists an equilibrium in which firms shroud add-on prices and sell the inferior product to consumers. In Section 4, we examine the implications of boundedly rational equilibrium beliefs for firms' innovation incentives. In Section 5, we briefly consider two extensions of our model. Section 6 concludes and discusses the implications of our results for mutual fund and credit/debit card markets. The Appendix contains all formal proofs.

2 Model

We analyze a market with horizontal product differentiation, superior and inferior products, as well as rational and boundedly rational consumers. To this end, we combine the Salop (1979) model of product differentiation with the multi-product model from HKM17. Following Spiegler (2016), we require that the behavior and beliefs of boundedly rational consumers constitute a personal equilibrium (which we define below).

Basic Framework. There is a unit mass of consumers. They are located uniformly on a circle with a perimeter equal to 1. Each consumer wants to buy at most one unit of a good. There are n firms $i = 1, ..., n$ located around the circle with equal distance between them. Each firm offers two products, a w-product and a v-product. A w-product generates utility w for a consumer and has unit production costs c^w, a v-product generates utility v and has unit costs c^v. Both products create positive gains from trade, but the v-product is inferior in the sense that $w - c^w > v - c^v > 0$. The utility from the v-product is large enough such that $v > w - c^w$. If a consumer purchases a u-product, $u \in \{w, v\}$, from firm i that is at distance d_i to her on the circle, and pays the total price p_i^u, then her payoff equals $u - p_i^u - td_i$. Let $D = (d_1, ..., d_n)$ denote a consumer's vector of distances to the n firms on the circle (we suppress notation for individual consumers). If a consumer does not purchase any product, she obtains a default option at price zero from the firm that is closest to her. Her payoff this is then $-t\min(d_1, ..., d_n)$.[2]

The total price p^w_i of firm i's w-product consists of a weakly positive base price $p^w_{i,b} \geq 0$. In contrast, the total price of its v-product p^v_i consists of a base price $p^v_{i,b} \geq 0$ and an add-on price $p^v_{i,o} \geq 0$ with (exogenous) maximal value $\bar{p}_o > 0$. Hence, we have $p^v_i = p^v_{i,b} + p^v_{i,o}$. Firm i's profit from its u-product is the mass of consumers who purchase it times the markup $p^u_i - c^u$.

Shrouded Prices and Boundedly Rational Consumers. Firms can hide their add-on prices or advertise them. Denote by $e_i \in \{0, 1\}$ firm i's advertising choice. If firm i advertises the add-on price of its v-product ($e_i = 1$), consumers can condition their product choice on both $p^v_{i,b}$ and $p^v_{i,o}$. If it hides it ($e_i = 0$), consumers only observe $p^v_{i,b}$ and have the belief $\tilde{p}^v_{i,o} \in [0, \bar{p}_o]$ about $p^v_{i,o}$. Denote by $P_i = (p^w_{i,b}, p^v_{i,b}, p^v_{i,o}, e_i)$ firm i's strategy, i.e., its price and advertising choices. Let $P = (P_1, ..., P_n)$ the strategy profile of all firms, and P_{-i} the strategy profile of firm i's rivals. For a given profile P let P^o be the part of P that consumers observe, i.e., all prices and advertising choices in P except the hidden add-on prices; $\mathbf{P}$ and $\mathbf{P}^o$ are the sets of all possible realizations of P and P^o, respectively. Let $\tilde{p} = (\tilde{p}^v_{1,o}, ..., \tilde{p}^v_{n,o})$ be the vector of consumers' beliefs about hidden add-on prices and $\mathbf{D}$ the set of all possible distance vectors D.

The sequence of events is as follows. First, firms choose their strategies simultaneously. Next, consumers make their purchase decision. If at least one firm advertises the add-on price of its v-product, all consumers are rational. Otherwise, consumers differ in their understanding of the firms' pricing schedules. Rational consumers anticipate that they may have to pay a positive add-on price only if they purchase a v-product. Boundedly rational consumers neglect the influence of product choice on the likelihood of add-on charges.

Let λ be the share of boundedly rational consumers. To capture their coarse perception of products, we introduce the following definitions. Denote by $a = (u, i)$ the product-firm combination that a consumer chooses, and by A the set of all possible product-firm combinations. This set also contains getting the default option from the closest firm, $a = (0, 0)$. Let $q \in \Delta(A)$ be a consumer's (possibly mixed) product choice. At a given firm strategy profile P, product choice q defines the probability q_1 with which she buys a product with positive hidden add-on price and the probability q_2 with which she buys a product without positive hidden add-on price (a w-product or a v-product with zero add-on price; the default option does not count as product). Let μ be the belief of a boundedly rational consumer that she has to pay a hidden positive add-on price if she purchases any product. This belief equals

$$\mu(q) = \frac{q_1}{q_1 + q_2}. \tag{1}$$

[2]The assumption that consumers have to acquire a default option from a firm is not essential for our main results. It simplifies the equilibrium analysis by ruling out cases where the market is not covered and firms are essentially monopolists. This modeling strategy has been considered first by Bénabou and Tirole (2016).

For the case $q_1 = q_2 = 0$ we assume $\mu = 1$. This assumption is not essential for our main results, but it simplifies the analysis substantially. A boundedly rational consumer's expected payoff from action $a = (u, i)$ is given by

$$U^{br}(a \mid q, D) = u - p^u_{i,b} - \mu(q)\tilde{p}^v_{i,o} - td_i. \tag{2}$$

The expected payoff from choosing the default option is independent of product choice q and equals $U^{br}(a = (0,0) \mid q, D) = -t \min(d_1, ..., d_n)$. Since μ depends on product choice q, we follow Spiegler (2016) and adopt a personal equilibrium concept. It requires that the boundedly rational consumer's product choice q must be optimal given her beliefs μ about the probability of add-on charges, and that these beliefs are derived from statistics generated (for example, in past play) from her product choice.

Definition 1 (Personal Equilibrium)**.** *The product choice $q \in \Delta(A)$ is a personal equilibrium at given firm strategy P, beliefs $\tilde{p}$, and distance vector D if $a \in \arg\max_{a' \in A} U^{br}(a' \mid q, D)$ for all $a \in A$ in the support of q and the belief μ is derived from q as indicated in equation (1).*

In a personal equilibrium, boundedly rational players may be wrong about the actions that firms choose. Specifically, they may overestimate the total price of a w-product. For this reason, our solution concept is different from self-confirming equilibrium (Fudenberg and Levine, 1993) which requires that the players' beliefs are correct on the equilibrium path.

We now can define the consumers' strategies and the market equilibrium. The rational consumers' strategy profile defines product choice as a function of observed firm choices and distances, $\sigma^r : \mathbf{P}^o \times \mathbf{D} \to \Delta(A)$. The boundedly rational consumers' strategy profile captures personal equilibria. It therefore defines product choice as a function of firm choices and distances, $\sigma^{br} : \mathbf{P} \times \mathbf{D} \to \Delta(A)$. We define the equilibrium of the game as follows.

Definition 2 (Market Equilibrium)**.** *The quadruple $\sigma = (P, \tilde{p}, \sigma^r, \sigma^{br})$ is an equilibrium if (i) the consumers' beliefs $\tilde{p}$ are consistent with P for all products with hidden add-on prices, (ii) strategy profile σ^r maximizes the rational consumers' payoff for all $P^o \in \mathbf{P}^o$ and $D \in \mathbf{D}$ at given $\tilde{p}$, (iii) σ^{br} constitutes a personal equilibrium for all $P \in \mathbf{P}$ and $D \in \mathbf{D}$ at given $\tilde{p}$, and (iv) for each firm i strategy P_i maximizes its profit for given P_{-i}, σ^r, and σ^{br}.*

We explain the intuition behind these definitions. Rational consumers base their product choice on the prices they observe and firms' advertising. Their product choice must be optimal given the beliefs about hidden add-on prices. The equilibrium definition requires that these beliefs are correct on the equilibrium path. If a firm changes its hidden add-on price off-equilibrium, this does not affect the rational consumers' choice. Their behavior in this model is consistent with that described in Gabaix and Laibson (2006) and Heidhues et al. (2017).

Boundedly rational consumers collect data to estimate the share of products with positive, hidden add-on prices. They use this share to infer the consequences of buying any product. Therefore, their strategy is based on all prices (not only observed ones). If a firm changes its hidden add-on price off-equilibrium, this does not affect the boundedly rational consumers' choice, except when the change is from a positive add-on price to zero (or from zero to a positive add-on price).[3] In this case, the change may affect beliefs μ and hence the boundedly rational consumers' personal equilibrium.

The first requirement of Definition 2 rules out surprise add-on charges on the equilibrium path: It cannot happen that firm i hides the add-on price of its v-product, charges $p^v_{i,o} = \bar{p}_o$, and the consumers' beliefs regarding this add-on price is $\tilde{p}^v_{i,o} < \bar{p}_o$. Further, Definition 1 and Definition 2 imply that a consumer's equilibrium payoff at least equals the value of her default option. This rules out that she pays (on average) more for products than she is willing to pay for them. Hence, there are no participation distortions in equilibrium. This has the following implication: In this model, firms cannot profitably sell useless products (i.e., products with non-positive gains from trade) in a pure strategy equilibrium. If they sell the u-product to some consumers at a total price that exceeds the production costs, $p^u > c^u$, the consumers' utility from the product must weakly exceed the price, $u \geq p^u$, so that we have $u - c^u > 0$. In contrast, both participation distortions and profitable trade of useless products may occur in this framework in equilibrium if boundedly rational consumers had myopic beliefs.

We call an equilibrium *symmetric* if all firms choose the same prices and advertising options, i.e., there exist values p^w_b, p^v_b, p^v_o, e such that each firm i chooses $P_i = (p^w_b, p^v_b, p^v_o, e)$. In a shrouding equilibrium, all firms hide their add-on prices. To simplify the analysis, we assume the following tie-breaking rules: In case of a tie between a w-product and a v-product (from any firm), consumers choose the w-product. In case of a tie between a u-product, $u \in \{w, v\}$, and the default option, consumers choose the u-product.

3 Equilibrium Trade of Superior and Inferior Products

We derive the main results of our model. In Subsection 3.1, we examine the benchmark case when all consumers are rational. In Subsection 3.2, we derive under what circumstances a shrouding equilibrium with inefficient trade exists.

[3] The interpretation of this assumption is as follows: If a firm chooses off-equilibrium a positive and hidden add-on price that differs from the consumers' belief about the hidden add-on price for this product, boundedly rational consumers treat this as a mistake by the firm. Hence, it does not affect their personal equilibrium.

3.1 The Benchmark Equilibrium Outcome

We first examine the equilibrium outcome when all consumers are rational. In this case, firms cannot gain from hiding add-on prices. If in equilibrium firm i shrouds the add-on price of its v-product and sells a positive quantity of it, rational consumers anticipate that its add-on price equals $\bar{p}_o$ and that its total price is $p_i^v = p_{i,b}^v + \bar{p}_o$. Given that in equilibrium all consumers correctly predict the total prices of all products, there is no scope for the trade of inferior products. Since the gains from trading the v-product are smaller than the gains from trading the w-product, it is not profitable for firms to sell the inferior product, regardless of the intensity of competition. Therefore, only the w-product is traded in equilibrium. The following result describes the market outcome – prices and profits – in a benchmark equilibrium.

Proposition 1 (Benchmark Equilibrium Outcome)**.** *Suppose all consumers are rational. Then only the w-product is traded in equilibrium. The unique equilibrium outcome is as follows:*

(i) If $\frac{t}{n} < w - c^w$, each firm charges $p^w = c^w + \frac{t}{n}$ and earns total profits of $\pi = \frac{t}{n^2}$.

(ii) If $\frac{t}{n} \geq w - c^w$, each firm charges $p^w = w$ and earns total profits of $\pi = \frac{1}{n}(w - c^w)$.

The proof of Proposition 1 is in Appendix A.1. Figure 1 displays the firms' individual profits in a symmetric equilibrium for the two cases. Case (i) is the standard case that is discussed in the literature on product differentiation. The degree of product differentiation is small enough such that firms are competing for consumers. Each firm's individual profit equals $\frac{t}{n^2}$. Thus, it strictly increases in t and converges to zero for $\frac{t}{n} \to 0$. In Case (ii), the degree of product differentiation is large enough so that, in equilibrium, firms charge the monopoly price and share the market equally. In this domain, a firm's individual profit no longer depends on the degree of product differentiation.

We consider a further useful benchmark. Suppose that all consumers are rational and that firms can only offer the v-product. Proposition 1 indicates the equilibrium outcome also for this case: We only have to replace w, c^w by v, c^v in the statement. Note that, at a low degree of product differentiation, $\frac{t}{n} \leq v - c^v$, the symmetric equilibrium profits in the two benchmark cases are identical. In this domain, competition is intense enough so that markups are determined only by $\frac{t}{n}$, while the gains from trade, $w - c^w$ and $v - c^v$, play no role for firm profits. In contrast, when the degree of product differentiation is large enough, $\frac{t}{n} > v - c^v$, the equilibrium profits from trading only the w-product strictly exceed those from trading only the v-product. Figure 1 illustrates this difference through the dashed line which indicates the symmetric equilibrium profits from trading the v-product.

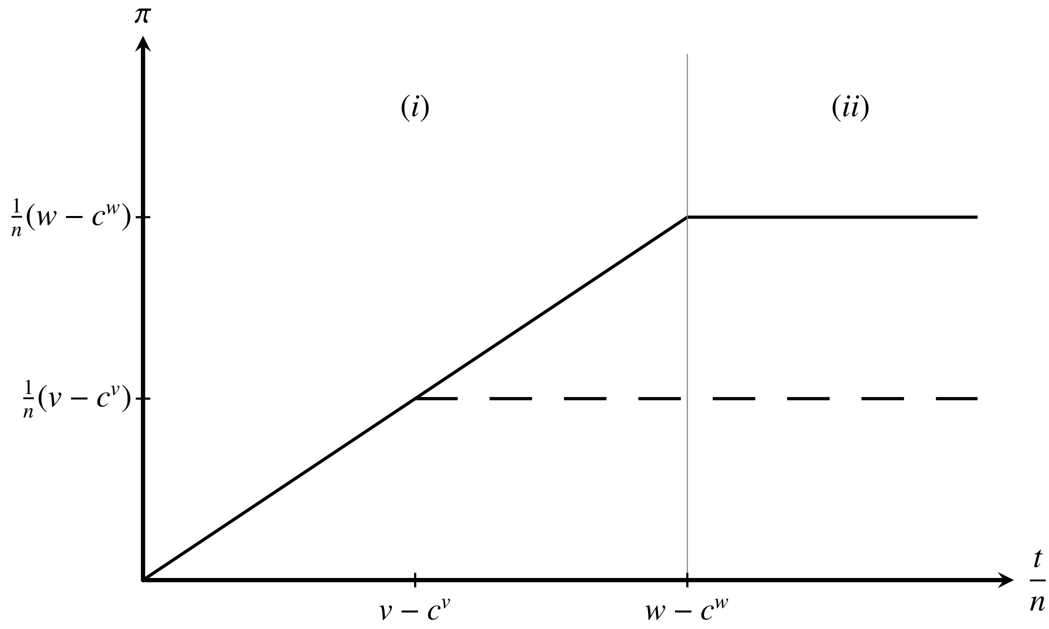

Figure 1: Individual firm profits from trading the w-product in a benchmark equilibrium (solid black line) and individual firm profits from trading the v-product in an equilibrium when only the v-product is available (dashed black line). The numbers (i) and (ii) indicate the cases from Proposition 1.

3.2 The Equilibrium with Boundedly Rational Consumers

We examine the market equilibrium when some consumers are boundedly rational. Note that the outcome from a benchmark equilibrium is always an equilibrium outcome. When all firms advertise their add-on prices and act as in a benchmark equilibrium, no firm can profit from shrouding an add-on price or from charging different prices. Hence, there always exists an equilibrium in which only the w-product is traded at the total prices indicated in Proposition 1.

How does the presence of boundedly rational consumers create scope for the trade of inferior products? Suppose firms choose the following strategy profile: All firms charge the same prices and shroud add-on prices. The total price of the w-product is positive and covers production costs c^w. The base price of the v-product is zero and its add-on price equals $\bar{p}_o$. Suppose the total prices of the two products are such that the w-product is the better deal for consumers and both products strictly dominate the default option, $w - p^w > v - p^v > 0$.

How would consumers react to this profile? Let us assume that consumers believe that any hidden add-on price takes on the maximal value $\bar{p}_o$. Rational consumers then anticipate the surplus from each product and hence purchase the w-product. Boundedly rational consumers may not correctly infer the total prices of the two products. Suppose that a boundedly rational consumer purchases the v-product with probability q_1 and the w-product with probability q_2. She then experiences add-on charges with probability $\mu = \frac{q_1}{q_1+q_2}$. As she does not take into account that the frequency of positive add-on charges varies in the product type, she believes that an add-on charge of $\bar{p}_o$ occurs with probability μ after any product purchase. Since we have $v > w - c^w$ and p^w covers the production cost of the w-product, we also have

$$v - \mu \bar{p}_o > w - p^w - \mu \bar{p}_o. \tag{3}$$

Thus, for any μ, the v-product appears as more attractive to the boundedly rational consumer than the w-product. Buying the w-product therefore does not constitute a personal equilibrium for her and purchasing the v-product is the only personal equilibrium for boundedly rational consumers in the considered assessment. We analyze under what circumstances there exists an equilibrium that features such an outcome.

Proposition 2 (Shrouding Equilibria with Inefficient Trade)**.** *Suppose there is a positive share of boundedly rational consumers.*

(i) If $\frac{t}{n} < \bar{p}_o - c^v$ and $\bar{p}_o \leq v$, then there exists a symmetric shrouding equilibrium in which rational consumers purchase the w-product at the total price $p^w = c^w + \frac{t}{n}$ and boundedly rational consumers purchase the v-product at base price $p_b^v = 0$ and add-on price $p_o^v = \bar{p}_o$.

(ii) If $\bar{p}_o - c^v \leq \frac{t}{n} \leq v - c^v$ and $\bar{p}_o > (w - c^w) - (v - c^v)$, then there exists a symmetric shrouding equilibrium in which rational consumers purchase the w-product at the total price $p^w = c^w + \frac{t}{n}$ and boundedly rational consumers purchase the v-product at base price $p_b^v = c^v + \frac{t}{n} - \bar{p}_o$ and add-on price $p_o^v = \bar{p}_o$.

(iii) If $\frac{t}{n} > v - c^v$, then only the w-product is traded in equilibrium. The prices for the w-product are the same as in a benchmark equilibrium.

The proof of Proposition 2 is in Appendix A.1. Figure 2 illustrates Proposition 2 by showing the profits that firms earn in a symmetric (shrouding) equilibrium. To facilitate the comparison, we normalize individual firm profits from the two products by the shares of rational and boundedly rational consumers, respectively.

Consider Case (i) where competition between firms is intense enough so that $\frac{t}{n} < \bar{p}_o - c^v$. In this case, there exists a shrouding equilibrium with the features described above. Firms sell the w-product to rational consumers at the competitive price $p^w = c^w + \frac{t}{n}$. To boundedly rational consumers they sell the v-product at the total price $p^v = \bar{p}_o$; its base price is zero and the add-on price is maximal. Each group of consumers is convinced to purchase the best deal in the market, but only for rational consumers this is actually true. An individual firm's profit in this shrouding equilibrium equals

$$\pi^{sh} = \frac{1}{n}\left[\lambda(\bar{p}_o - c^v) + (1 - \lambda)\frac{t}{n}\right]. \tag{4}$$

The firms' strategies support an equilibrium due to the logic outlined in HKM17: Firms earn higher profits from boundedly rational consumers than from rational consumers. In Figure 2, the difference in profits is displayed by the black solid and the red solid line. It does not pay off for firms to educate consumers in order to sell them the superior w-product since this product can only be sold at relatively low markups. Observe that, at $\frac{t}{n} \approx 0$, firms earn positive profits almost exclusively from selling the inferior product.

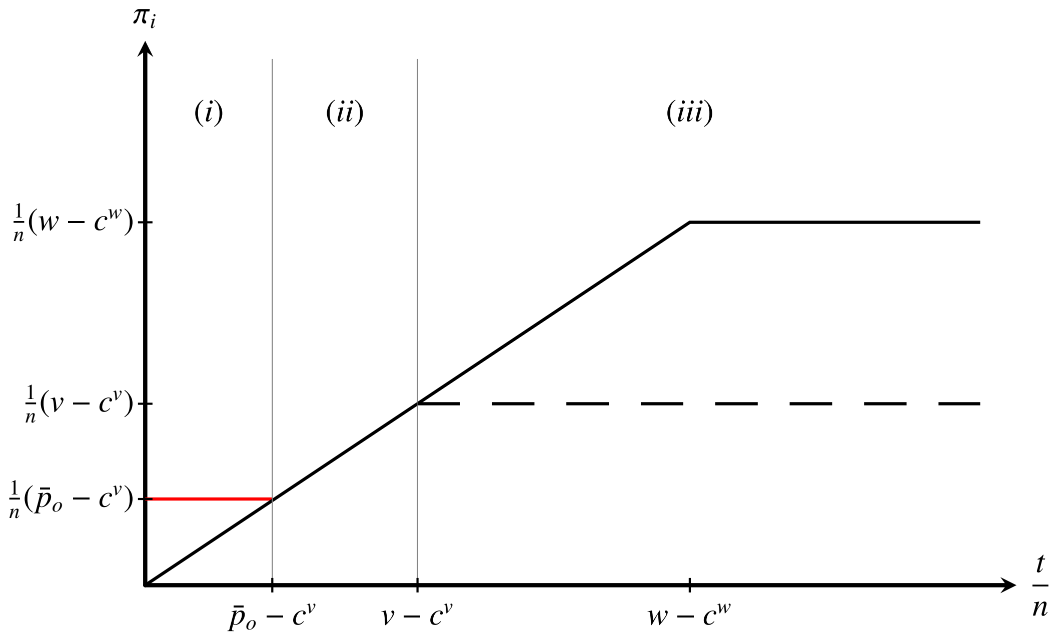

Figure 2: Normalized individual firm profits from trading the v-product in a symmetric shrouding equilibrium from Proposition 2 (red line); normalized individual firm profits from trading the w-product in a benchmark (or symmetric shrouding) equilibrium (solid black line); and individual firm profits from selling the v-product in a benchmark equilibrium when only the v-product is available (dashed black line). The numbers (i) to (iii) indicate the cases from Proposition 2.

Next, consider Case (ii) where the level of product differentiation is such that $\bar{p}_o - c^v \leq \frac{t}{n} \leq v - c^v$. In this region, there still can exist a symmetric shrouding equilibrium in which firms sell the inferior product to boundedly rational consumers. However, in this equilibrium, firms no longer benefit from hiding add-on prices. The equilibrium markup on both the w-product and the v-product equals $\frac{t}{n}$. To charge this markup on the v-product, firms typically have to choose a positive base price. That is, competitive pressure is no longer enough to reduce the base price of the v-product to zero. Moreover, the maximal add-on price $\bar{p}_o$ must be large enough so that the v-product still appears as the superior deal to boundedly rational consumers.

Finally, consider Case (iii) where competition is sufficiently relaxed so that $\frac{t}{n} > v - c^v$. A shrouding equilibrium in which the inferior product is sold to some consumers then no longer exists. The reason for this is that, in this region, firms earn higher profits from selling the w-product at the competitive price than from selling the v-product at any price. To see this, suppose that $v - c^v < \frac{t}{n} \leq w - c^w$ (the case $\frac{t}{n} > w - c^w$ works similarly). Here the competitive price of the w-product is $p^w = c^w + \frac{t}{n}$ and a firm's normalized profit from selling the w-product to rational consumers is $\pi^w = \frac{t}{n^2}$. The total price for the v-product that maximizes the sum of firms' profits in this region is $p^v = v$ and the corresponding normalized firm profit from selling it to boundedly rational consumers is $\pi^v = \frac{1}{n}(v - c^v)$. The inequality $\frac{t}{n} > v - c^v$ is equivalent to

$$\pi^w = \frac{t}{n^2} > \frac{1}{n}(v - c^v) = \pi^v. \tag{5}$$

Hence, in the symmetric shrouding assessment from above, each firm would have an incentive to educate consumers in order to sell the w-product to both consumer groups.

The significance of Proposition 2 is that it shows when the shrouding equilibrium from the multi-product version of HKM17 obtains in an environment where all consumers correctly predict their equilibrium expenses. For this, two conditions must be satisfied. First, the maximal add-on price must not exceed the value of the inferior product to consumers, $\bar{p}_o \leq v$. As boundedly rational consumers take the add-on price into account, they would not purchase the v-product if this condition were violated.

Second, competition must be sufficiently intense. This is different from a model where the boundedly rational consumers exhibit myopic beliefs. Suppose they had myopic beliefs, $\mu = 0$ (regardless of q). A symmetric shrouding equilibrium with inefficient trade would then exist at all degrees of competition $\frac{t}{n}$ as long as the maximal add-on price satisfies $\bar{p}_o > (w-c^w)-(v-c^v)$; see Appendix A.2 for details. Firms would strictly benefit from selling the inferior product to myopic consumers even if competition is relaxed. In particular, if $\frac{t}{n}$ is sufficiently large, firms can profitably charge both the monopoly price and the maximal add-on charge $\bar{p}_o$ to myopic consumers. A positive share of these consumers then earns a payoff below the default option value from purchasing the v-product.

In our version of the shrouding equilibrium, boundedly rational consumers do not learn anything on the equilibrium path that would inform them about the misspecification in their reasoning. Therefore, the equilibrium outcome can persist even if these consumers repeatedly purchase the inferior product and experience its consequences. Further, boundedly rational consumers understand in equilibrium how firms earn positive profits with the v-product. In contrast, if they had myopic beliefs, they would think that firms are selling the v-product at a loss, which at some stage may make them suspicious about the true nature of the transaction.

Proposition 2 yields us another important implication. Observe from equation (4) that the firm's profit in the symmetric shrouding equilibrium of Case (i) strictly increases in the maximal add-on price $\bar{p}_o$. This holds as long as it does not exceed the utility v from the inferior product. The model therefore generates a maximal add-on price that is optimal for firms, in the sense that it maximizes the firms' profit in the considered shrouding equilibrium. In the following, we call it the "optimal add-on price."

Corollary 1 (Optimal Add-On Price)**.** *Suppose that $\frac{t}{n} \leq v - c^v$ and $\bar{p}_o \leq v$. Consider the symmetric shrouding equilibrium from Proposition 2. All else equal, the firms' profit in this equilibrium is maximal if $\bar{p}_o = v$.*

At the optimal add-on price, boundedly rational consumers pay their valuation v for the inferior product. Thus, at $\frac{t}{n} \approx 0$, rational consumers reap almost the maximal surplus $w - c^w$, while boundedly rational consumers earn no surplus at all. Further, a firm's profit at the optimal add-on price in the considered shrouding equilibrium equals

$$\tilde{\pi}^{sh} = \frac{1}{n}\left[\lambda(v - c^v) + (1 - \lambda)\frac{t}{n}\right]. \tag{6}$$

For now, the optimal add-on price is only a theoretical value that does not emerge endogenously in equilibrium. However, in the next section, we will see that it may be chosen in equilibrium if firms can invest into exploitative innovation.

4 Innovation Incentives

An important question in industrial organization is whether firms have incentives to invest into product improvements and new technologies. Research and development are important sources of economic growth and generally benefit society. However, the trade of inferior products in a shrouding equilibrium may undermine firms' innovation incentives. In this section, we study firms' incentives to invest into exploitative innovation (which raises the maximal add-on price) and product innovation. To this end, we closely follow the model of HKM16, which examines innovation incentives with myopic consumers. This allows to cleanly identify the different implications of boundedly rational equilibrium and myopic beliefs for firms' innovation incentives and welfare.

Exploitative Innovation. Firms may be able to increase the maximal add-on price, for example, by creating new contract terms and add-on charges (e.g., new overdraft fees or extraordinary penalty payments for certain credit card transactions) or by inventing new ways to circumvent industry regulations. HKM16 call such developments "exploitative innovation." In their model, myopic consumers do not take add-on charges into account when making a purchase decision. They also do not anticipate price changes that originate from exploitative innovation. The model in HKM16 therefore captures innovation incentives for novel technologies and fees when consumers are unaware of the firms' new add-on charges.

In the following, we study incentives for exploitative innovation under the premise that all consumers quickly learn about the existence of new add-on charges and adjust their beliefs $\tilde{p}$ accordingly. We ignore the learning period (where potentially both rational and boundedly rational consumers are initially surprised by the new charges) so that we can use the model from Section 2. We add an additional stage to the dynamic game. Before firms set their prices and choose their advertising strategies, there is an "innovation stage" where firm 1 can invest into an exploitative innovation project. Only one project is available and after its completion, the innovation can be used by all firms.[4] Exploitative innovation increases the maximal add-on price from $\bar{p}_o$ to $\bar{p}_o^{new} > \bar{p}_o$. After the innovation stage, the game continues with the realized level of the maximal add-on price: $\bar{p}_o^{new}$ if firm 1 realized the innovation project and $\bar{p}_o$ otherwise. We assume that the continuation equilibrium after the innovation stage equals the symmetric shrouding equilibrium from Proposition 2 whenever it exists; otherwise, the equilibrium is a benchmark equilibrium from Proposition 1. Firm 1 is willing to invest a positive amount into the innovation project if doing so increases its profit in the continuation equilibrium after the innovation stage. We obtain the following result from our previous findings.

Corollary 2 (Exploitative Innovation)**.** *Consider the exploitative innovation extension of our model with a positive share of boundedly rational consumers and suppose that* $\frac{t}{n} < v - c^v$.

(i) If $\bar{p}_o^{new} > c^v + \frac{t}{n}$ *and* $\bar{p}_o^{new} \leq v$*, firm 1 is willing to invest a positive amount into exploitative innovation.*

(ii) If $\bar{p}_o^{new} \leq c^v + \frac{t}{n}$ *or if* $\bar{p}_o^{new} > v$*, firm 1 is not willing to invest a positive amount into exploitative innovation.*

As long as the exploitative innovation project closes the gap between the actual maximal add-on price $\bar{p}_o$ and the optimal add-on price v, there are incentives to invest into exploitative innovation as in HKM16. However, these incentives disappear as the maximal add-on prices reaches its optimal level. Beyond this threshold, the willingness to pay for exploitative innovation is negative since the symmetric shrouding equilibrium would collapse and firms would earn lower profits after the innovation. Therefore, if firms could continuously invest into exploitative innovation, the optimal add-on price v would define the limit of their efforts.

Product Innovation. We again assume that there is an additional stage where firm 1 can invest into an innovation project before the market opens. This innovation is then available to all firms. Firm 1 can invest into increasing the utility of each product: w-product innovation

[4]We therefore focus on non-appropriable innovation. For our main application – financial services – this is the empirically relevant case for innovation projects. In their main result (Proposition 2), HKM16 also focus on non-appropriable innovation.

(v-product innovation) increases the utility of the w-product (v-product) from w to $w^{new} > w$ (from v to $v^{new} > v$). We assume that $v > w^{new} - c^w$ and $v^{new} - c^v < w - c^w$ (we drop the latter assumption below). The continuation equilibrium after the innovation stage again equals the symmetric shrouding equilibrium from Proposition 2 whenever it exists; otherwise, it is a benchmark equilibrium from Proposition 1. The following result provides an overview under what circumstances firm 1 would invest into product innovation.

Corollary 3 (Product Innovation)**.** *Consider the product innovation extension of our model with a positive share of boundedly rational consumers and suppose that $\frac{t}{n} \leq v - c^v$.*

(i) Firm 1 is not willing to invest a positive amount into w-product innovation.

(ii) If the maximal add-on price $\bar{p}_o \leq v$ is given, firm 1 is not willing to invest a positive amount into v-product innovation.

(iii) Assume that $\bar{p}_o$ equals the optimal add-on price in the continuation game after the innovation stage. Firm 1 is then willing to invest $\frac{\lambda}{n}(v^{new} - v) > 0$ into v-product innovation.

Corollary 3 directly follows from the profit functions in equation (4) and equation (6). First, there are no incentives to invest into w-product innovation. As in a benchmark equilibrium, the markup on this product is $\frac{t}{n}$, regardless of its value to consumers. Since any gain from innovation would be passed on to rational consumers, firm 1 has no incentive to invest into w-product innovation. Next, firm 1 also has no incentive to invest into v-product innovation as long as the maximal add-on price $\bar{p}_o$ is fixed. Since it cannot profitably increase the total price for the v-product, only boundedly rational consumers would benefit from an improvement of the inferior product.

This changes when the add-on price can be kept at the optimal level v through continuous exploitative innovation. Firm 1 is then willing to invest a positive amount into v-product innovation. Intuitively, the combination of exploitative and product-innovation means that firm 1 offers more value to boundedly rational consumers and reaps the additional gains from trade by adjusting prices in a way so that competition does not threaten the increase in profits. Thus, exploitative innovation and product innovation can be complements.

Reversal of Welfare Ranking. Product innovation reduces the welfare-loss from the trade of inefficient products. However, to what extent do innovation incentives persist if the v-product offers more gains from trade than the w-product after the innovation has taken place (i.e., if $v^{new} - c^v > w - c^w$)? In the following, we consider this case. Again, we assume that the maximal add-on price always equals the optimal add-on price in the continuation equilibrium after the innovation stage. This continuation equilibrium is the symmetric shrouding equilibrium from

Proposition 2 if it exists. Otherwise, it equals a benchmark equilibrium from Proposition 1. We obtain the following result for this setting.

Proposition 3 (Innovation Incentives)**.** *Consider the product innovation extension of our model. Suppose there is a positive share of boundedly rational consumers, we have $\frac{t}{n} \leq v - c^v$, and that after the innovation stage $\bar{p}_o$ equals the optimal add-on price.*

(i) Firm 1 is not willing to invest a positive amount into w-product innovation.

(ii) There is a value $H > w - c^w$ so that firm 1 is willing to invest a positive amount into v-product innovation if and only if $v^{new} - c^v \leq H$.

The proof of Proposition 3 is in Appendix A.1. The restriction on the gains from trade of the (improved) v-product is due to the fact that, in a symmetric shrouding equilibrium, each firm may have an incentive to educate the boundedly rational consumers and to sell only the v-product. By doing so, a firm would able to serve a larger fraction of consumers since it sells the superior product while all other firms only sell the (now) inferior w-product to consumers. To illustrate the restriction on the two products, consider the case where $\frac{t}{n} = 0$. If all firms stick to the strategies of the symmetric shrouding equilibrium, each firm earns a profit of $\frac{\lambda}{n}(v^{new} - c^v)$. If firm i educates consumers and sells the v-product at the optimal price to all consumers (while all other firms adhere to the prescribed strategy), its profit equals $(v^{new} - c^v) - (w - c^w)$. This deviation is unprofitable if and only if

$$\frac{n}{n-\lambda}(w - c^w) \geq v^{new} - c^v. \tag{7}$$

Note that the requirement on the relative gains from trade tightens as the number of firm n increases. For large n, the symmetric shrouding equilibrium only exists if the two products offer roughly the same benefits.

We draw two important conclusions from Proposition 3. First, the presence of boundedly rational consumers may provide innovation incentives which go beyond the elimination of welfare-losses that are due to inefficient trade. It can therefore lead to more welfare than in a competitive market with only rational consumers. The intuition follows Schumpeter's proposed link between market structure and R&D investments (Schumpeter, 1943, Gilbert, 2006). Boundedly rational consumers create the market power necessary to make investments into innovation profitable. In particular, this holds for non-appropriable innovation. Thus, the presence of boundedly rational consumers can have a similar effect as patent protection.

Second, innovation incentives for the v-product are limited. If the gains from trade from the v-product are too large relative to those from the w-product, this creates an incentive to educate all consumers and to serve a larger fraction of rational and boundedly rational consumers than in the symmetric shrouding equilibrium. If the symmetric shrouding equilibrium is no longer sustainable, then in equilibrium firms charge the competitive markup $\frac{t}{n}$. Therefore, firm 1 refrains from innovation projects that would "destroy" the symmetric shrouding equilibrium.

Overall, our results on innovation incentives offer a more positive perspective on markets with shrouded add-on prices than the previous literature: There are incentives for exploitative innovation, but they vanish as the maximal add-on price approaches its optimal value. Continuous exploitative innovation creates incentives for firms to increase the value of the inferior product, which reduces the welfare loss that is due to its trade. These innovation incentives not only reduce the welfare-loss from inefficient trade, but may even lead to a better market outcome than if all consumers were rational.

5 Extensions

Shrouded Add-on Prices and Substitution Effort. The canonical model of add-on pricing with myopic consumers is GL06. In this model, firms offer only one type of product. This product comes with a base and an add-on price, which firms can hide or advertise. If at least one firm advertises its add-on price, all consumers are rational. Otherwise, a positive share of consumers is myopic. Consumers have the option to exert costly substitution effort in order to avoid paying the add-on price. Myopic consumers do not anticipate this price and therefore also do not exert substitution effort. GL06 show that if the share of myopic consumers is sufficiently large, there exists a shrouding equilibrium in which firms hide the add-on price, rational consumers exert substitution effort, and myopic consumers end up paying the add-on price. The framework of GL06 has been used and extended in many papers.[5]

In Appendix A.3, we adapt our framework to the GL06 model. Here we explain three insights from this extension. First, we establish that the main result from GL06 does not depend on the assumption of myopic consumers. If competition is fierce enough and the share of boundedly rational consumers is sufficiently large, then there is a symmetric shrouding equilibrium in which boundedly rational consumers pay both the base and the maximal add-on price, while rational consumers exert substitution effort so that they only pay the base price. The important difference to the original result is that, in our framework, boundedly rational consumers anticipate the add-on price. They just do not know how to avoid it.

Second, we show that a shrouding equilibrium only exists if, for a given share of boundedly

[5]In particular, Armstrong and Vickers (2012), Dahremöller (2013), Shulman and Geng (2013), Zenger (2013), Heidhues and Kőszegi (2017), Ko and Williams (2017), Kosfeld and Schüwer (2017), Herweg and Rosato (2020), and Johnen (2020b) directly build on the GL06 framework.

rational consumers, the market is competitive enough. Formally, if for given λ the ratio $\frac{t}{n}$ is sufficiently large, firms prefer to unshroud add-on prices so that they can profitably sell the add-on also to rational consumers who otherwise would exert substitution effort. As in our baseline model, when firms enjoy sufficient market power, they want to avoid consumer choices that reduce the gains from trade.

Finally, the GL06 framework lends itself to study price discrimination between myopic and rational consumers. Johnen (2020b) analyzes a dynamic setting where firms learn their customers' types and can tailor later offers to this information. He shows that a firm's informational advantage against its rivals translates into monopoly power and positive profits even when firms compete in Bertrand manner. To obtain this result, it is assumed that myopic consumers remain myopic even after experiencing surprise add-on charges. Our version of the GL06 framework implies that such an assumption is not needed. The myopic consumers in the original GL06 framework and the boundedly rational consumers in the present model behave in the same way in a shrouding equilibrium as long as the maximal add-on price is not too large. Hence, it is possible to obtain the main results from Johnen (2020b) in a framework where consumers do not experience surprise charges.

Alternative Formulation of Equilibrium Beliefs. In our baseline model, boundedly rational consumers apply the same add-on charge probability $\mu(q)$ across all products. One can generalize our model of belief formation to allow for beliefs that are partially dependent on the add-on price of a particular product. We briefly examine the implications of such a generalization. Consider a boundedly rational consumer with product choice q that generates (at given prices) the probability of hidden add-on charges μ as defined in equation (1). The boundedly rational consumer's belief about the probability of a positive add-on charge after purchasing the u-product from firm i is given by

$$\mu_{u,i} = \chi\mu(q) + (1-\chi)\mathbf{1}(p_i^u > p_{i,b}^u), \tag{8}$$

where $\mathbf{1}$ is the indicator function and $\chi \in [0,1]$ a measure for the consumer's level of bounded rationality. For $\chi = 1$ the consumer has the same beliefs as in our baseline model, while for $\chi = 0$ she correctly anticipates for each product whether there is a positive hidden add-on charge or not (Eyster and Rabin, 2005 use a similar parametrization to define partially cursed equilibrium beliefs).

We examine when the symmetric shrouding equilibrium from Proposition 2 Case (i) still exists under this alternative formulation of equilibrium beliefs. Suppose competition is intense enough such that $\frac{t}{n} < \bar{p}_o - c^v$ and assume that firms behave in the same manner as described in the statement. Under the alternative belief formation model, boundedly rational consumers still prefer the v-product to the w-product in a personal equilibrium if

$$v - \bar{p}_o > w - \left(c^w + \frac{t}{n}\right) - \chi \bar{p}_o. \tag{9}$$

Thus, the smaller is χ, the more attractive the w-product appears to boundedly rational consumers. We rewrite this inequality and get

$$\chi > \frac{(w - c^w - \frac{t}{n}) - (v - \bar{p}_o)}{\bar{p}_o} \equiv \chi^*. \tag{10}$$

As in the proof of Proposition 2 we can show that the suggested shrouding equilibrium exists if $\chi > \chi^*$.[6] Further, from inequality (10) we obtain the following observation: For any given $\chi > 0$ we have $\chi > \chi^*$ if the gains from trade of the inferior product $v - c^v$ are close enough to the gains from trade of the superior product $w - c^w$ and the maximal add-on price $\bar{p}_o$ is sufficiently close to $c^v + \frac{t}{n}$. This means that for any degree of rationality $\chi > 0$ and any specification of the w-product w, c^w we can find a specification of the v-product v, c^v and a maximal add-on price $\bar{p}_o$ such that a symmetric shrouding equilibrium exists (provided the market is sufficiently competitive) and firms earn strictly higher profits in this equilibrium than in a benchmark equilibrium. Thus, shrouding add-on prices can be profitable for firms even if the behavioral consumers are close to fully rational. Of course, for $\chi \to 0$ the maximal firm benefits from shrouding add-on prices converge to zero.

6 Conclusion

The existence of large and hidden add-on charges in competitive markets is difficult to reconcile with fully rational consumers. To study such markets, it therefore has been suggested that a share of consumers does not take the add-on charges of certain services into account. While such an assumption is reasonable for one-time transactions, it is less convincing when consumers use a product frequently, or when firms need to build up reputation and thus wish to avoid large discrepancies between consumer expectations and their actual experiences.

We studied a market with add-on pricing where boundedly rational consumers correctly anticipate their expenses in equilibrium, but may falsely predict how these expenses would change if they chose an alternative product. The core results from the hidden add-on pricing literature obtain in this model, but only if the market is sufficiently competitive. The model generates a natural prediction for the maximal add-on price, a variable that is usually taken as

[6] This result can potentially be further generalized. One may allow for more heterogeneity by having a group of consumers with values of χ around zero and a group of consumers with $\chi > \chi^*$. To study this generalization, one needs to define the effect of add-on price advertising on the consumers' level of rationality χ.

given in the literature. We showed that firms have limited incentives to invest into exploitative innovation, and that continuous exploitative innovation creates incentives to improve products even if innovation is non-appropriable. These product innovation incentives are strong enough to improve welfare in the shrouding equilibrium beyond the rational consumer benchmark level. Our model rationalizes several empirical findings from the mutual fund market as well as from credit/debit card markets. In the following, we briefly discuss these markets.

Price effects of index fund entry. Mutual funds are either actively managed funds where a fund manager decides about investments, or index funds that passively follow some stock index. Index funds are typically less costly in terms of management fees and often outperform actively managed funds, e.g., Fama and French (2010). Therefore, index funds can be interpreted as the superior and actively managed funds as the inferior product.

Our model captures well the price effects triggered by index fund market entry. Actively managed funds exist since many decades, while index funds have been introduced only gradually since the 1970s. Sun (2021) analyzes the prices of mutual funds and investment flows in the different market segments when an index fund becomes available. She exploits the staggered timing of index fund market entry in the different equity categories. Her main findings on prices and investment flows are as follows: In response to an index fund entry, the management fees of actively managed funds decrease when they are sold directly, but increase by roughly the same amount when they are sold through financial advisors. Actively managed funds significantly lose market share among investors who invest directly. Financial advisors hardly recommend any index funds.

These developments are consistent with the results from our model. Suppose the actively managed fund is the inferior v-product, the index fund is the superior w-product, and that $c^v > c^w$. As long as only the inferior v-product is available, all consumers have the same beliefs about its costs and payoffs, so that it is sold at the competitive price $p^v = c^v + \frac{t}{n}$. When the superior w-product is introduced and the market enters a profitable shrouding equilibrium, rational consumers switch to the cheaper w-product which trades at the competitive price $p^w = c^w + \frac{t}{n} < c^v + \frac{t}{n} = p^v$. Boundedly rational consumers stick to the v-product, but pay a higher price for it when $\bar{p}_o > c^v + \frac{t}{n} = p^v$.

Fees and transparency regulation. Even consumers with little experience may know about the existence of management fees. In their audit study, Mullainathan et al. (2012) find that many financial advisors mention fees in the discussion with the client, even when the "client" (the auditor) has not (yet) asked about them. Typically, advisors then downplay these fees by explaining that the product is worth its costs. Hence, they can inform consumers about management fees without educating them about the difference between product types. This fits the setting of the present model where boundedly rational consumers anticipate the total price of the product they are purchasing, but not the total price of alternative products.

Further, public policy tries to increase consumer surplus in the market for mutual funds by improving transparency. Since January 2018, the European Union imposes substantial requirements on companies that engage in financial advisory through an updated "Markets in Financial Instruments Directive" (Directive 2014/65/EU, henceforth MiFID II). MiFID II implements multiple regulations regarding the business model of financial advice, compensation schemes, product governance, and transparency. With respect to fees, it forces firms to disclose all costs of a product before the consumer purchases it, and also during the contractual relationship (Article 24(4)(c) of MiFID II). Thus, even when a consumer does not digest all material that firms must provide due to MiFID II, the existence of fees is made salient to her.

The effects of MiFID II on consumer behavior have not been analyzed yet and there exist few empirical studies on the general impact of the regulation. An exception is Loonen (2021). He conducts a survey with 267 Dutch investment advisors. In particular, he asks about how advisors evaluate the effect of different MiFID II measures on investor protection. Cost transparency is evaluated by 26.5 percent as positive or very positive for investor protection, by 44.2 percent as neutral, and by 29.2 percent of advisors as negative or very negative. Thus, there seems to be no consensus to what extent cost transparency helps investors.

Trust and reputational concerns. Mutual funds are often sold indirectly through brokers who also offer investment advice to their clients. A growing literature argues that the relationship to the financial advisor is important for the client who seeks investment advice. Gennaioli et al. (2015) argue that the main role of financial advisors is not to provide information, but to act as "money doctors" who help clients making risky investments by reducing their anxiety about taking risk. They "are trusted to do so even when their advice is costly, generic, and occasionally self-serving" (Gennaioli et al., 2015, page 92). Consumers seeking advice pay substantial fees on investment products only if they sufficiently trust their advisor.

Given that firms benefit from their clients' trust, they are interested in maintaining a good relationship with their clients. Kostovetsky (2016) shows that for retail investors the relationship to the fund management matters. If the ownership of a mutual fund changes, there are significant outflows of investments following the announcement date. This effect is particularly pronounced for mutual funds with high management fees. Choi and Robertson (2020) find that two of the most important factors that determine the share invested in equity is trust in market participants and trust in financial advisors. Overall, a reduction in trust reduces investments in equity, e.g., Gurun et al. (2018).

Our model with boundedly rational consumers shows that there is not necessarily a conflict between reputational concerns and the trade of inferior products since consumers only incur expected charges. In contrast, if consumers were myopic, the ongoing trade of mutual funds with high add-on charges would continuously surprise consumers and produce disappointed (less wealthy than expected) customer generations. This would be at odds with an industry that is very concerned with its reputation.

Effects of Informational Interventions. The fee structure of credit and debit cards has frequently been cited as an exploitative business practice by regulators and academics alike. Therefore, a number of studies examined whether informational interventions improve consumer behavior. If consumers have myopic beliefs and do not take add-on charges into account, then highlighting them in recurring messages should significantly reduce credit card debt and the use of overdrafts. The empirical support for this prediction is mixed. Several studies on credit card usage find no significant effects of informational interventions (Agarwal et al., 2015, Seira et al., 2017, Adams et al., 2022). Some papers on debit card usage report modest reductions of overdrafting (Stango and Zinman, 2014, Alan et al., 2018, Grubb et al., 2025). Gathergood et al. (2021) find in administrative data (spanning two years of credit card use) that some consumers learn to avoid fees by choosing an appropriate contractual arrangement, while others regularly incur high fees. From the perspective of the present model, informing consumers about add-on charges that they incur on a regular basis is not effective since they already take them into account. However, informing them about better alternatives may alter their behavior if it updates their way of thinking about personal finances.

Product and process innovation in the credit card industry. An important implication of our model is that there is scope for non-appropriable product innovation. Indeed, the credit card industry has produced significant innovations in the last decades. First, credit card issuers continuously implement new technologies to prevent fraud. In fact, credit card fraud decreased substantially[7], despite the ever increasing volume of e-commerce and payments over the internet. This development is partly due to new standards for customer authentication. As a result, credit cards nowadays provide better protection against fraud for consumers than debit cards. Second, there are a number of recent innovations that facilitate payments and borrowing for consumers, e.g., contactless payments, payments through wearables like smartwatches, virtual credit cards, QR code-based payments, as well as "masked cards" that protect the user's privacy against data brokers.

[7]See, for example, the 2021 Report on Credit Card Fraud by the European Central Bank.

A Appendix

A.1 Omitted Proofs

Proof of Proposition 1. The proof proceeds in four steps. In Step 1, we prove that, in equilibrium, firms only sell the w-product to consumers. In Step 2, we derive the symmetric equilibrium outcome when $\frac{t}{n} < w - c^w$. In Step 3, we show that this is also the unique equilibrium outcome. In Step 4, we derive the symmetric equilibrium outcome when $\frac{t}{n} \geq w - c^w$ and show that it is unique.

Step 1. We first show that only the w-product is traded in equilibrium. Assume by contradiction that an equilibrium exists in which firm i sells the v-product to a positive share of consumers at total price p_i^v. The tie-breaking rule implies that firm i does not sell the w-product to any consumer. Now consider the following deviation: Firm i advertises its add-on price and offers the w-product at total price p_i^w with $w - p_i^w = v - p_i^v$, so that consumers are indifferent between the w-product from firm i at total price p_i^w and the v-product from firm i at total price p_i^v. Note that firm i then sells the w-product to (at least) the same share of consumers as in the original equilibrium. By assumption, we have

$$p_i^w - c^w = w - v + p_i^v - c^w = p_i^v - (v - (w - c^w)) > p_i^v - c^v, \tag{11}$$

where the last inequality follows from the fact that $w - c^w > v - c^v$. Thus, the deviation is profitable for firm i, a contradiction. In the following steps, we therefore can ignore firms' prices for the v-product.

Step 2. We derive a symmetric equilibrium outcome when $\frac{t}{n} < w - c^w$. The consumer who is indifferent between firm i and its neighbor firm j at the total prices p_i^w, p_j^w is defined by

$$w - p_i^w - td_i = w - p_j^w - t\left(\frac{1}{n} - d_i\right). \tag{12}$$

Thus, if all firms other than firm i charge p_{-i}^w, then demand for firm i's w-product equals $R_i = \frac{p_{-i}^w - p_i^w}{t} + \frac{1}{n}$. From this, we get that there is a symmetric equilibrium in which all firms charge the total price $p^w = c^w + \frac{t}{n}$. Each firm earns $\pi = \frac{1}{n}(p^w - c^w) = \frac{t}{n^2}$ in this equilibrium. Further, observe that $\frac{t}{n} < w - c^w$ implies $p^w < w$ so that no consumer can increase her payoff by choosing the default option.

Step 3. We show that the equilibrium outcome is unique when $\frac{t}{n} < w - c^w$. Assume by contradiction that there is an equilibrium in which some firm i charges a total price $p_i^w > c^w + \frac{t}{n}$. Assume w.l.o.g. that firm i charges the highest total price and each firm serves a positive share of consumers in this equilibrium. We show that firm i can deviate profitably by lowering its total price. To this end, we consider firm i's profit $\tilde{\pi}_i$ from trading with consumers on the interval between firm i and any given neighboring firm j. If $p_i^w > w$, no consumer would trade with firm i, which cannot happen in equilibrium. Given that $p_i^w \le w$, the marginal consumer on the interval between firm i and firm j is characterized by equality (12). We then have

$$\tilde{\pi}_i = (p_i^w - c^w)\left(\frac{p_j^w - p_i^w}{2t} + \frac{1}{2n}\right). \tag{13}$$

The profit $\tilde{\pi}_i$ strictly decreases in p_i^w if

$$c^w + \frac{t}{n} < 2p_i^w - p_j^w, \tag{14}$$

which, by the assumption on firms' total prices, is satisfied. Hence, there cannot be an equilibrium in which any firm i charges a total price $p_i^w > c^w + \frac{t}{n}$.

Next, assume by contradiction that there is an equilibrium in which some firm i charges a total price $p_i^w < c^w + \frac{t}{n}$. Assume w.l.o.g. that firm i charges the lowest total price and each firm serves a positive share of consumers in this equilibrium. We show that firm i can deviate profitably by increasing its price. By the arguments above, we must have $p_j^w \le c^w + \frac{t}{n}$ for all firms j in this equilibrium. We again consider firm i's profit $\tilde{\pi}_i$ from trading with consumers on the interval between firm i and any given neighboring firm j. Firm i's marginal consumer on this interval must be indifferent between trading with firm i and firm j, and earn strictly positive surplus. This consumer is defined by equality (12) and $\tilde{\pi}_i$ is given by equation (13). The profit $\tilde{\pi}_i$ strictly increases in p_i^w if

$$c^w + \frac{t}{n} > 2p_i^w - p_j^w, \tag{15}$$

which, by the assumption on firms' total prices, is satisfied. Thus, firm i can profitably increase its price, a contradiction. This completes the proof of the statement.

Step 4. We show that if $\frac{t}{n} \ge w - c^w$, then the unique equilibrium outcome is that all firms charge $p^w = w$ and each firm earns $\pi = \frac{1}{n}(w - c^w)$. Assume by contradiction that there is an equilibrium in which some firm i charges a total price $p_i^w \ne w$. If $p_i^w > w$, then no consumer trades with firm i, which cannot be an equilibrium outcome. Suppose $p_i^w < w$ and assume w.l.o.g. that firm i charges the lowest total price. By using similar arguments as in Step 3, we then can show that firm i could deviate profitably by increasing its price, a contradiction. □

Proof of Proposition 2. The proof proceeds in six steps. In Step 1, we prove statement (i). In Step 2, we prove statement (ii). In Step 3 to Step 6, we prove statement (iii).

Step 1. We prove statement (i). For this, we consider the assessment where all firms hide their add-on prices and charge the base and add-on prices $p_b^w = c^w + \frac{t}{n}$, $p_b^v = 0$, and $p_o^v = \bar{p}_o$; consumers expect that hidden add-on prices always take on the maximal value, $\tilde{p}_{i,o}^v = \bar{p}_o$ for all $i \in \{1, ..., n\}$. Note that the restrictions $\frac{t}{n} < \bar{p}_o - c^v$ and $\bar{p}_o \leq v$ imply that we have $\frac{t}{n} < v - c^v$. Hence, we also have $\frac{t}{n} < w - c^w$. Thus, in the considered assessment, rational consumers prefer the w-product to the default option and boundedly rational consumers prefer the v-product to the default option in a personal equilibrium.

We show that no party has a profitable deviation in the considered assessment. The assumption that $\frac{t}{n} < \bar{p}_o - c^v$ and the fact that $w - c^w > v - c^v$ imply

$$w - \left(c^w + \frac{t}{n}\right) > v - \bar{p}_o. \tag{16}$$

Hence, rational consumers prefer the w-product to the v-product. As discussed in the main text around equation (3), boundedly rational consumers purchase the v-product in a personal equilibrium since we have $v > w - c^w$ and therefore

$$v - \bar{p}_o > w - \left(c^w + \frac{t}{n}\right) - \bar{p}_o. \tag{17}$$

Finally, the restriction $\frac{t}{n} < \bar{p}_o - c^v$ ensures that firms earn strictly higher profits from selling the v-product at the total price $p^v = \bar{p}_o$ to boundedly rational consumers than from selling the w-product at the total price $p^w = c^w + \frac{t}{n}$ to these consumers. Thus, by Proposition 1, no firm can gain by advertising its add-on price and/or charging different prices. Hence, the considered assessment is part of an equilibrium.

Step 2. We prove statement (ii). For this, we consider the assessment where all firms hide their add-on prices and charge the base and add-on prices $p_b^w = c^w + \frac{t}{n}$, $p_b^v = c^v + \frac{t}{n} - \bar{p}_o$, and $p_o^v = \bar{p}_o$; consumers expect that hidden add-on prices always take on the maximal value, $\tilde{p}_{i,o}^v = \bar{p}_o$ for all $i \in \{1, ..., n\}$. Note that, under these prices, rational consumers prefer the w-product to the default option and boundedly rational consumers prefer the v-product to the default option.

We examine the consumers' choices in this assessment. Rational consumers prefer the w-product to the v-product if

$$w - \left(c^w + \frac{t}{n}\right) > v - \left(c^v + \frac{t}{n}\right). \tag{18}$$

This inequality is satisfied due to the assumption that $w - c^w > v - c^v$. Next, boundedly rational consumers prefer the v-product to the w-product in a personal equilibrium if

$$v - \left(c^v + \frac{t}{n}\right) > w - \left(c^w + \frac{t}{n}\right) - \bar{p}_o. \tag{19}$$

This inequality holds due to the assumption that the maximal add-on price is large enough so that $\bar{p}_o > (w - c^w) - (v - c^v)$.

We now can show that no firm has a profitable deviation. The total prices that firms charge in this assessment imply that firms earn the same profit from trading the w-product and the v-product. Prices are determined by competition between firms as in a benchmark equilibrium from Proposition 1. Thus, no firm can gain by advertising its add-on price and/or charging different prices. Hence, the considered assessment is part of an equilibrium.

Step 3. Suppose that $\frac{t}{n} > v - c^v$. Assume by contradiction that there exists an equilibrium in which firm i only sells the v-product at total price p_i^v to a positive share of consumers. In equilibrium, we then must have that firm i sells to a positive share of rational consumers (otherwise, firm i could profitably sell the w-product to some rational consumers) and that $p_i^v > c^v$. Suppose now that firm i offers the w-product at the total price

$$p_i^w = p_i^v - (v - w) - \varepsilon. \tag{20}$$

If $\varepsilon > 0$ is sufficiently small, then the following holds: At least the rational consumers who in the proposed equilibrium trade with firm i now purchase the w-product from firm i and firm i earns strictly higher profits with this deviation since $w - c^w > v - c^v$ implies $p_i^w - c^w > p_i^v - c^v$ when equation (20) holds, a contradiction. Hence, if $\frac{t}{n} > v - c^v$, then in equilibrium each firm sells the w-product to a positive share of consumers.

Step 4. If in equilibrium firm i sells both the w-product and the v-product to positive shares of consumers, it sells the w-product to rational and the v-product to boundedly rational consumers. This follows from the utility function in equation (2) and the tie-breaking rules.

Step 5. Suppose that $\frac{t}{n} > v - c^v$. Assume by contradiction that there exists an equilibrium in which firm i sells the w-product at a price below the rational benchmark level to a positive share of consumers, i.e., $p_i^w < c^w + \frac{t}{n}$ if $\frac{t}{n} \leq w - c^w$ and $p_i^w < w$ if $\frac{t}{n} > w - c^w$. Assume w.l.o.g. that firm i charges the lowest total price for the w-product. By Step 4, firm i's profit equals

$$\pi_i = \pi_i^{br} + \pi_i^r = \lambda(p_i^u - c^u)(G_{i1}^{br} + G_{i2}^{br}) + (1 - \lambda)(p_i^w - c^w)(G_{i1}^r + G_{i2}^r), \tag{21}$$

where π_i^{br}, π_i^r are firm i's profits from boundedly rational and rational consumers, respectively; G_{i1}^{br}, G_{i2}^{br} are the shares of boundedly rational consumers located on the left and ride side of firm i on the circle who purchase a product from firm i; and G_{i1}^r, G_{i2}^r are the corresponding values for rational consumers. Here, $u \in \{w, v\}$ denotes the product that boundedly rational consumers purchase from firm i.

Assume first that $u = v$. Using similar arguments as in the proof of Proposition 1, we can show that firm i then can deviate profitably by increasing the total price p_i^w. A sufficiently small raise would increase π_i^r, while leaving π_i^{br} unchanged (since boundedly rational consumers would not change their behavior). Next, assume that $u = w$. Note that the boundedly rational consumers who trade with firm i potentially underestimate the total price of the firms' v-products. Therefore, firm i can deviate profitably by educating consumers and increasing the total price p_i^w. Taking these statements together yields us the contradiction.

Step 6. Suppose that $\frac{t}{n} > v - c^v$. Assume by contradiction that an equilibrium exists in which a firm sells the v-product to a positive share of consumers. Consider first any firm i that only sells the w-product to consumers (if such a firm exists). Note that the share of boundedly rational consumers it serves must be at least as large as the share of rational consumers, $G_{i1}^{br} + G_{i2}^{br} \geq G_{i1}^r + G_{i2}^r$, otherwise firm i could gain by educating consumers. By the previous steps, all of firm i's rivals charge at least the rational benchmark level for the w-product. Hence, the optimal total price for the w-product for firm i is such that the share of rational consumers it serves is at least $\frac{1}{n}$. Next, consider any firm j that sells the v-product to boundedly rational consumers. Since all firms charge at least the rational benchmark level for the w-product, this firm can earn at least the benchmark equilibrium profit out of rational consumers. Since $\frac{t}{n} > v - c^v$, it earns weakly more out of boundedly rational consumers only if the share of boundedly rational consumers it serves exceeds $\frac{1}{n}$. By the observations above, this cannot be the case for all firms that sell the v-product. Hence, at least one of them could profitably deviate by educating consumers and charging different prices, a contradiction. The last sentence of statement (iii) can by shown by using similar arguments as the proof of Proposition 1. □

Proof of Proposition 3. Statement (i) follows directly from the firms' equilibrium prices defined in Proposition 1 and Proposition 2. In the following, we prove statement (ii). Suppose firm 1 completed the innovation project. Consider the symmetric shrouding equilibrium after the innovation stage: All firms hide their add-on prices and charge the base and add-on prices $p^w = c^w + \frac{t}{n}$, $p_b^v = 0$, and $p_o^v = \bar{p}_o = v^{new}$. Consumers expect $\tilde{p}_{i,o}^v = \bar{p}_o$ for all $i \in \{1, ..., n\}$. We show that the firm strategy profile is part of an equilibrium if and only if $v^{new} - c^v$ is sufficiently close to $w - c^w$. Statement (ii) then follows directly from this finding. The rest of the proof proceeds in three steps.

Step 1. We examine under what circumstances rational consumers purchase the w-product while boundedly rational consumers purchase the v-product. Rational consumers strictly prefer the w-product to the v-product if

$$w - \left(c^w + \frac{t}{n}\right) > v^{new} - \bar{p}_o = 0. \tag{22}$$

Since $\frac{t}{n} < v - c^v < w - c^w$ this inequality is satisfied. Boundedly rational consumers prefer the

v-product to the w-product if

$$v^{new} - \bar{p}_o \geq w - \left(c^w + \frac{t}{n}\right) - \bar{p}_o, \tag{23}$$

which is implied by the assumption that $v^{new} - c^v > w - c^w$. Since $\bar{p}_o = v^{new}$ all consumers weakly prefer either the w-product or the v-product to their default option.

Step 2. Consider any firm i. Given the proposed firm strategy profile, firm i may have an incentive to advertise $p^v_{i,o}$ and to sell only the v-product to consumers. In the following, we show that such a deviation is unprofitable if and only if $v^{new} - c^v$ is sufficiently close to $w - c^w$. To this end, we first derive the optimal total price of the v-product for this deviation, assuming that all other firms comply to the strategy proposed at the beginning of the proof. By Step 1, rational consumers strictly prefer the w-product from a firm $j \neq i$ to the v-product from firm j. In the following, we assume that the number of firms n is an odd number (the proof for even n is very similar). The optimal total price of the v-product is (a) either a corner solution and makes the consumers at the location of a firm $j \neq i$ indifferent between the v-product from firm i and the w-product from firm j, or (b) an interior solution. To characterize the optimal total price for case (a) define by $x \geq 1$ the number of segments between firm i and a firm $j \neq i$ on the shortest path. The highest such number is given by $\frac{n-1}{2}$. Define $X = \{1, ..., \frac{n-1}{2}\}$. If consumers at the location of firm $j \neq i$ are indifferent between the v-product from firm i and the w-product from firm j, and firm j is x segments away from firm i, we have

$$v^{new} - p^v_i - x\frac{t}{n} = w - \left(c^w + \frac{t}{n}\right) \tag{24}$$

and hence $p^v_i = v^{new} - (w - c^w) - (x - 1)\frac{t}{n}$. The corresponding profit is

$$\pi^a_i(x) = \left((v^{new} - c^v) - (w - c^w) - (x - 1)\frac{t}{n}\right)(2x + 1)\frac{1}{n}. \tag{25}$$

Next, we characterize the optimal total price for case (b). In this case, firm i's marginal consumers are defined by

$$v^{new} - p^v_i - t\left((x^* - 1)\frac{1}{n} + d_i\right) = w - \left(c^w + \frac{t}{n}\right) - t\left(\frac{1}{n} - d_i\right), \tag{26}$$

where x^* is the number of segments between firm i and a firm j so that marginal consumers are located on the segment adjacent to firm j and on the path between firm i and firm j. The optimal total price equals $p^v_i = \frac{(v^{new}+c^v)-(w-c^w)}{2} + \frac{t}{n}\frac{x^*+1}{2}$ and the corresponding profit is

$$\pi^b_i = \frac{1}{t}\left(\frac{(v^{new} - c^v) - (w - c^w)}{2} + \frac{t}{n}\frac{x^* + 1}{2}\right)^2, \tag{27}$$

where $x^* = \left\lfloor \frac{n}{3t}[(v^{new} - c^v) - (w - c^w)] + 1 \right\rfloor$.[8] The maximal profit from the deviation is

$$\pi^{dev} = \max\left\{\pi_i^a(x), \pi_i^b \mid x \in X\right\}. \tag{28}$$

Next, a firm's profit from compliance to the considered strategy is

$$\pi^{com} = \frac{1}{n}\left[\lambda(v^{new} - c^v) + (1-\lambda)\frac{t}{n}\right]. \tag{29}$$

If $v^{new} - c^v$ is sufficiently close to $w - c^w$, the profit π^{dev} defined above is given by

$$\pi^{dev} = \frac{1}{t}\left(\frac{(v^{new} - c^v) - (w - c^w)}{2} + \frac{t}{n}\right)^2. \tag{30}$$

At $v^{new} - c^v = w - c^w$ this value is $\pi^{dev} = \frac{t}{n^2}$. Note that $\frac{t}{n^2} < \pi^{com}$ is equivalent to $\frac{t}{n} < v^{new} - c^v$. This inequality is satisfied since we have $\frac{t}{n} < w - c^w$ and hence also $\frac{t}{n} < v^{new} - c^v$. Thus, by continuity, if $v^{new} - c^v$ is sufficiently close to $w - c^w$, we have $\pi^{dev} < \pi^{com}$. It remains to prove the "only if" part of the statement. Note that π^{dev} is piecewise continuous in v^{new} and π^{com} is continuous in v^{new}. We can verify that π^{dev} increases faster in v^{new} than π^{com}. Hence, there is exactly one intersection of π^{dev} with π^{com}. The corresponding value of v^{new} defines H.

Step 3. We prove that the considered firm strategy profile is part of an equilibrium if and only if $v^{new} - c^v$ is sufficiently close to $w - c^w$. By Proposition 1, firms cannot gain by charging a different total price for the w-product. Firms also cannot gain by charging different base and add-on prices for the v-product. Given the consumers' beliefs about hidden add-on prices, the result then follows directly from Step 2. This completes the proof. □

A.2 The Model with Myopic Consumers

We examine a version of our model where boundedly rational consumers have myopic beliefs. This means that they attach probability zero to the event that they have to pay an add-on charge after purchasing any product. Formally, we have $\mu = 0$, regardless of product choice q. In equilibrium, the boundedly rational consumers' product choice must be a personal equilibrium according to Definition 1 at given belief $\mu = 0$. The rest of the model from Section 2 remains the same. For convenience, we suspend the first tie-breaking rule. By using similar arguments as in the proofs of Propositions 1 and 2, we obtain the following result.

[8]This value is defined by the segment furthest away from firm i so that consumers at the beginning of this segment weakly prefer the v-product from firm i at the total price p_i^v (stated above) to the w-product from the closest firm.

Proposition 4 (Myopic Consumers)**.** *Suppose that there is a share of boundedly rational consumers and that these consumers have myopic beliefs. If $\bar{p}_o > (w-c^w)-(v-c^v)$, then there exists a symmetric shrouding equilibrium in which rational consumers purchase the w-product and boundedly rational consumers purchase the v-product. The total price p^w for the w-product is set as indicated in Proposition 1. The total price p^v for the v-product is set as follows.*

(i) If $\frac{t}{n} < \bar{p}_o - c^v$, boundedly rational consumers purchase the v-product at total price $p^v = \bar{p}_o$ with $p^v_b = 0$ and $p^v_o = \bar{p}_o$.

(ii) If $\bar{p}_o - c^v \leq \frac{t}{n} \leq v - c^v + \bar{p}_o$, boundedly rational consumers purchase the v-product at total price $p^v = c^v + \frac{t}{n}$ with $p^v_b = c^v + \frac{t}{n} - \bar{p}_o$ and $p^v_o = \bar{p}_o$.

(iii) If $\frac{t}{n} > v - c^v + \bar{p}_o$, boundedly rational consumers purchase the v-product at total price $p^v = v + \bar{p}_o$ with $p^v_b = v$ and $p^v_o = \bar{p}_o$.

A.3 Shrouded Add-on Prices and Substitution Effort

Setup. We adapt the GL06 model to our framework. Firms offer only the v-product and the unit cost of this product equals c. Each firm i charges a base price $p_{i,b} \in \mathbb{R}$ and an add-on price $p_{i,o} \geq 0$ with (exogenous) maximal value $\bar{p}_o > 0$ for the product. It can advertise its add-on price or not. If firm i advertises its add-on price, all consumers observe both $p_{i,b}$ and $p_{i,o}$. Otherwise, they only observe $p_{i,b}$ and form the belief $\tilde{p}_{i,o}$ about $p_{i,o}$. Consumers who purchase the v-product can choose whether to exert substitution effort in order to avoid the add-on charge. This effort creates personal costs of $\kappa > 0$ for the consumer.

To model boundedly rational equilibrium beliefs, we proceed as in Section 2. Boundedly rational consumers neglect the influence of substitution effort on the likelihood of paying an add-on charge. Denote by $a = (s, i)$ the effort-firm combination that a consumer chooses, where $s = 1$ ($s = 0$) indicates that the consumer exerts (does not exert) substitution effort. Let A be the set of possible effort-firm combinations. This set also contains getting the default option from the closest firm, $a = (0, 0)$. Let $q \in \Delta(A)$ be a consumer's product choice. At given firm prices, q defines the probability q_1 with which she buys a product (not the default option) with positive add-on price and does not exert substitution effort as well as the probability q_2 with which she buys a product with zero add-on price *or* buys a product with positive add-on price and exerts substitution effort. The belief μ of a boundedly rational consumer about the probability of paying an add-on price after buying a product is given by equation (1). For the case $q_1 = q_2 = 0$ we assume $\mu = 1$. The personal equilibrium concept from Definition 1 naturally extends to this setting. We assume that the maximal add-on price is strictly larger than the costs of substitution effort, $\bar{p}_o > \kappa$. As in the original model, if all firms shroud their add-on prices, boundedly rational consumers remain boundedly rational. If at least one firm advertises its add-on price, all boundedly rational consumers become rational. The rest of the model (sequence of events, equilibrium definition) is the same as in Section 2. In case of a tie between a v-product (from any firm) and the default option, consumers choose the v-product.

Shrouding Equilibria. To examine the existence and features of shrouding equilibria, we proceed in two steps. First, we assume that firms cannot advertise add-on prices and characterize the equilibrium outcome for this case. Second, we consider the full model where firms can advertise add-on prices and analyze under what circumstances the equilibrium outcome from the first step is indeed an equilibrium outcome of the full model.

We begin with the first step. Given that firms cannot advertise add-on prices, they choose the maximal possible add-on price $\bar{p}_o$ in equilibrium. Since $\bar{p}_o > \kappa$, rational consumers exert substitution effort and only pay the base price $p_{i,b}$ when they trade with firm i. Boundedly rational consumers do not understand that substitution effort would help them to avoid add-on charges. Since substitution effort is costly, they are not performing it and end up paying both the base and the add-on price, $p_{i,b} + \bar{p}_o$, when they trade with firm i. Given the consumers' behavior, we can determine the equilibrium outcome for all levels of competition.

Lemma 1 (Shrouding Equilibrium Outcome)**.** *Consider the model with substitution effort and suppose there is a positive share of boundedly rational consumers. Assume that firms cannot advertise their add-on prices and that λ is large enough such that $\lambda(v-c) \geq (1-\lambda)\bar{p}_o$. The unique equilibrium outcome is then as follows:*

(i) If $\frac{t}{n} \leq (v-c)-(1-\lambda)\bar{p}_o$, firms serve all consumers and charge the base price

$$p_b = c + \frac{t}{n} - \lambda\bar{p}_o.$$

(ii) If $\frac{t}{n} > (v-c)-(1-\lambda)\bar{p}_o$, firms serve all consumers and charge the base price

$$p_b = v - \bar{p}_o.$$

Proof of Lemma 1. We first prove statement (i). Assume that the marginal rational and boundedly rational consumers are indifferent between the two neighboring firms and weakly prefer the v-product to their default option. If all other firms charge the base price $p_{-i,b}$, then the demand for firm i's v-product from both rational and boundedly rational consumers at base price $p_{i,b}$ is equal to $R_i = \frac{p_{-i,b}-p_{i,b}}{t} + \frac{1}{n}$, and firm i's profit is given by

$$\pi_i = \lambda(p_{i,b} + \bar{p}_o - c)\left(\frac{p_{-i,b} - p_{i,b}}{t} + \frac{1}{n}\right) + (1-\lambda)(p_{i,b} - c)\left(\frac{p_{-i,b} - p_{i,b}}{t} + \frac{1}{n}\right). \quad (31)$$

From this equation we get that, in a symmetric equilibrium, each firm charges the base price $p_b = c + \frac{t}{n} - \lambda \bar{p}_o$. Given this price, the initial assumption on firm i's marginal consumers is correct. The uniqueness of the equilibrium outcome follows from standard arguments which show that at a higher (lower) base price firms have an incentive to cut (increase) their base price. Next, we prove statement (ii). Suppose that firms charge the base price $p_b = v - \bar{p}_o$. We show that no firm then can increase its profit by charging a different base price. Note that a firm's profit from compliance is

$$\pi^{com} = \lambda(v-c)\frac{1}{n} + (1-\lambda)(v-c-\bar{p}_o)\frac{1}{n}. \tag{32}$$

By using similar arguments as in Step 1, we can show that no firm can increase its profit by charging a base price below $v - \bar{p}_o$. If firm i charges a price above $v - \bar{p}_o$, it serves only rational consumers (or no consumers at all) and its profit is strictly less than

$$\pi^{dev} = (1-\lambda)(v-c-\kappa)\frac{1}{n}. \tag{33}$$

The assumption $\lambda(v-c) \geq (1-\lambda)\bar{p}_o$ ensures that $\pi^{com} \geq \pi^{dev}$. Hence, firm i cannot profitably increase its base price above $v - \bar{p}_o$. Again, standard arguments show that there is no other equilibrium outcome. □

The restriction on the share λ is not essential for Lemma 1, but it saves us from a few more case distinctions. To what extent do shrouding equilibria survive if firms are allowed to educate consumers? In the original result, shrouding add-on prices survives competitive pressure if there are sufficiently many myopic consumers. These consumers subsidize the base good. If one firm advertises its add-on price, they would realize that they can get advantageous deals when they exert substitution effort. If there are many myopic consumers, the unshrouding firm cannot profitably match these deals due to the large subsidy in the base price. We study whether this logic also applies in our framework and obtain the following result.

Proposition 5 (Shrouding Equilibria in the Model with Substitution Effort)**.** *Consider the model with substitution effort and suppose there is a positive share of boundedly rational consumers. Assume that λ is large enough such that $\lambda(v-c) \geq (1-\lambda)\bar{p}_o$.*

(i) If $\frac{t}{n} \leq (v-c) - (1-\lambda)\bar{p}_o$, there exists a symmetric shrouding equilibrium whenever $\lambda \geq \frac{\kappa}{\bar{p}_o}$.

(ii) If $\frac{t}{n} > (v-c) - (1-\lambda)\bar{p}_o$ and $\lambda \geq \frac{\kappa}{\bar{p}_o}$, then there is a value $\lambda^*(\frac{t}{n}) \geq \frac{\kappa}{\bar{p}_o}$ such that (A) a symmetric shrouding equilibrium exists whenever $\lambda \geq \lambda^*(\frac{t}{n})$ and (B) no shrouding

equilibrium exists whenever $\lambda < \lambda^*(\frac{t}{n})$. Furthermore, $\lambda^*(\frac{t}{n})$ strictly increases in $\frac{t}{n}$ and we have $\lambda^*(\frac{t}{n}) \to 1$ for $\frac{t}{n} \to \infty$.

Proof of Proposition 5. We prove the two statements in two steps.

Step 1. We prove statement (i). Assume that $\lambda\bar{p}_o \geq \kappa$ and that it is indeed optimal for firms to shroud add-on prices. By Lemma 1 and the assumption $\frac{t}{n} \leq (v-c)-(1-\lambda)\bar{p}_o$, we must have that, in a shrouding equilibrium, firms charge the base price $p_b = c + \frac{t}{n} - \lambda\bar{p}_o$, the maximal add-on price $\bar{p}_o$, and each firm earns a profit of

$$\pi^{com} = \frac{t}{n^2}. \tag{34}$$

Suppose firm i unshrouds its add-on price and charges w.l.o.g. an add-on price of zero. We derive the optimal base price for this deviation. Since $\lambda\bar{p}_o \geq \kappa$, firm i's profit would be negative if it charges $p_{i,b}$ small enough such that it serves consumers at distance $d_i \geq \frac{1}{n}$. Hence, under the optimal base price $p_{i,b}$, the marginal consumers for firm i are defined by

$$v - p_{i,b} - td_i = v - p_b - \kappa - t\left(\frac{1}{n} - d_i\right). \tag{35}$$

The share of consumers it serves then equals $R_i = \frac{c+\frac{t}{n}-\lambda\bar{p}_o+\kappa-p_{i,b}}{t} + \frac{1}{n}$. Its profit from charging $p_{i,b}$ is $\pi_i = (p_{i,b} - c)R_i$, and the optimal base price equals

$$\hat{p}_{i,b} = c + \frac{t}{n} - \frac{\lambda\bar{p}_o - \kappa}{2}. \tag{36}$$

Therefore, the highest possible profit from deviation (if it is weakly positive) equals

$$\pi^{dev} = \left(\frac{t}{n} - \frac{\lambda\bar{p}_o - \kappa}{2}\right)\left(\frac{1}{n} - \frac{\lambda\bar{p}_o - \kappa}{2t}\right). \tag{37}$$

From equations (34) and (37) we get that no firm can deviate profitably from the proposed symmetric shrouding profile whenever $\lambda\bar{p}_o \geq \kappa$. This completes the proof of the statement.

Step 2. We prove statement (ii). We prove it separately for two cases: Case (i) $\frac{t}{n} \leq (v-c)+(\bar{p}_o-\kappa)$ and Case (ii) $\frac{t}{n} > (v-c)+(\bar{p}_o-\kappa)$. First, consider Case (i). Lemma 1 implies that, in a shrouding equilibrium, each firm charges the base price $p_b = v - \bar{p}_o$, the maximal add-on price $\bar{p}_o$, and earns the profit

$$\pi^{com} = \lambda(v-c)\frac{1}{n} + (1-\lambda)(v-c-\bar{p}_o)\frac{1}{n}. \tag{38}$$

Given these prices, each firm may have an incentive to advertise its add-on price and to charge a different total price. Suppose that firm i unshrouds its add-on price and charges w.l.o.g. an add-on price of zero. We derive the optimal base price for this deviation. Since $\lambda \bar{p}_o \geq \kappa$, firm i's profit would be negative if it charges $p_{i,b}$ small enough such that it serves consumers at distance $d_i \geq \frac{1}{n}$. Hence, under the optimal base price $p_{i,b}$, the marginal consumers for firm i are defined by the equation

$$v - p_{i,b} - td_i = v - (v - \bar{p}_o) - \kappa - t\left(\frac{1}{n} - d_i\right). \tag{39}$$

The share of consumers it serves then equals $R_i = \frac{v - p_{i,b} - \bar{p}_o + \kappa}{t} + \frac{1}{n}$. Its profit from charging $p_{i,b}$ is $\pi_i = (p_{i,b} - c)R_i$ and the optimal base price equals $\hat{p}_{i,b} = \frac{1}{2}(v + c + \frac{t}{n} - \bar{p}_o + \kappa)$. The condition $\frac{t}{n} \leq (v - c) + (\bar{p}_o - \kappa)$ ensures that $\hat{p}_{i,b}$ does not exceed v. The highest profit from deviation is

$$\pi_1^{dev} = \frac{(v - c + \frac{t}{n} - \bar{p}_o + \kappa)^2}{4t}. \tag{40}$$

We have that $\pi^{com} \geq \pi_1^{dev}$ is equivalent to

$$\lambda \geq 1 - \frac{v - c}{\bar{p}_o} + \frac{1}{\frac{t}{n}\bar{p}_o}\left(\frac{v - c + \frac{t}{n} - \bar{p}_o + \kappa}{2}\right)^2. \tag{41}$$

The right-hand side of this inequality defines $\lambda^*(\frac{t}{n})$ for $\frac{t}{n} \leq (v - c) + (\bar{p}_o - \kappa)$. This yields us part (A) and part (B) of statement (ii) for Case (i). We can verify that $\lambda^*(\frac{t}{n}) = \frac{\kappa}{\bar{p}_o}$ at $\frac{t}{n} = (v - c) - (1 - \lambda)\bar{p}_o$ with $\lambda = \frac{\kappa}{\bar{p}_o}$, and that $\lambda^*(\frac{t}{n})$ strictly increases in $\frac{t}{n}$ on its domain.

Next, consider Case (ii). Lemma 1 again implies that, in a shrouding equilibrium, each firm charges the base price $p_b = v - \bar{p}_o$, the maximal add-on price $\bar{p}_o$, and earns the profit π^{com} as defined in equation (38). As above, we derive the optimal base price for a firm i that deviates by unshrouding its add-on price and w.l.o.g. charging an add-on price of zero. This base price is now given by $\hat{p}_{i,b} = v$ and the corresponding profit equals

$$\pi_2^{dev} = (v - c)\frac{1}{n} - (v - c)\frac{\bar{p}_o - \kappa}{t}. \tag{42}$$

We have that $\pi^{com} \geq \pi_2^{dev}$ is equivalent to

$$\lambda \geq 1 - \frac{(v - c)(\bar{p}_o - \kappa)}{\frac{t}{n}\bar{p}_o}. \tag{43}$$

The right-hand side of this inequality defines $\lambda^*(\frac{t}{n})$ for $\frac{t}{n} > (v - c) + (\bar{p}_o - \kappa)$. This yields us part (A) and part (B) of statement (ii) for Case (ii). We can verify that $\lambda^*(\frac{t}{n})$ strictly increases in $\frac{t}{n}$ on its domain and that $\lambda^*(\frac{t}{n}) \to 1$ for $\frac{t}{n} \to \infty$. This completes the proof. □

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