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Partial shrouding in asymmetric markets*

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Abstract

This paper studies shrouding of add-on information in a market where firms differ in add-on production costs. We show that partial shrouding equilibria, characterised by a selection result, exist: Firms with high (low) add-on costs shroud (unshroud). Unshrouding firms charge lower base-good prices than shrouding firms.

Keywords: Add-on pricing; Shrouding; Bounded rationality
JEL-Classification: D40; D80; L10

1 Introduction

It has been recognised that in many markets consumer information and transparency on prices can be heavily influenced by firms' strategies. In a recent paper, Gabaix and Laibson (2006), henceforth GL, consider an industry where firms sell a base good and add-on, and analyse firms' incentives to

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shroud add-on information.[1] They show that, independent of the intensity of competition, shrouding equilibria exist where no firm has an incentive to educate consumers about high add-on prices.

The present paper considers such shrouding decisions in a market where firms differ in their marginal costs of producing the add-on. We also depart from GL in that the number of myopic consumers who become educated by unshrouding increases with the number of unshrouding firms.

We find similar equilibria as in GL for high and low levels of myopic consumers. For high (low) levels of myopic consumers symmetric shrouding (unshrouding) equilibria exist where all firms shroud (unshroud) add-on information. Unilke GL, for intermediate levels of myopic consumers, partial shrouding equilibria exist where only a subset of firms shrouds. A selection result occurs: The subset of unshrouding (shrouding) firms contains those with the lowest (highest) add-on production cost. The reason behind this selection result is that a firm with a large add-on productivity has larger incentives to unshroud add-on information as it benefits to a larger extent from an increase in add-on sales by sophisticated consumers due to unshrouding.

In a partial shrouding equilibrium, unshrouding firms behave more aggressively than shrouding firms, charging lower base-good prices and obtaining a larger market share. This is novel as one would usually suspect the shrouding firms (who have a high add-on price) to charge low base-good prices. However, due to our selection result, this is overturned. Even though unshrouding firms sell the add-on at a lower price, they have a higher add-on profitability due to lower cost and hence larger incentive to compete tough on the base-good market.[2]

The paper contributes to the growing literature on obfuscation choices by firms. Most of this literature focusses on symmetric firm environments, but few consider cost asymmetries. Dahremöller (2013) considers asymmetric

[1]Prominent examples for such markets are retail financial markets, for instance, current accounts and overdraft fees as an add-on, or credit cards with late fees as the add-on.

[2]A potential application of the model might be the car market. Typically, a buyer faces the price of the base version of a car, and after having selected a car, the car dealer often tries to sell additional packages as add-on. The results of the paper would then suggest that less efficient car manufacturers have larger incentives to sell more complex packages or packages comprising a larger number of less useful features.

add-on costs in a duopoly market, but assumes a sequential time structure where shrouding decisions are made before pricing decisions. He finds that in such a setting only unshrouding equilibria exist. In contrast, in our paper, also partial shrouding equilibria exist. It is thus an empirical question which predictions can be supported by evidence. Heidhues et al. (2014) propose a model where asymmetric firms sell a single product whose price consists of two components, but focuses on symmetric shrouding equilibria. Wilson (2010) shows that also in symmetric environments asymmetric obfuscation choices can arise to relax price competition among firms.

2 The model

The model is based on Gabaix and Laibson (2006), but differs in two dimensions. First, we consider an industry where firms differ with respect to add-on costs. Second, we consider an alternative unshrouding mechanism where the share of myopic consumers who becomes educated due to unshrouding depends on the number of unshrouding firms.

Consider an oligopoly market where $n \geq 2$ firms offer a base good and an add-on. Each consumer demands at most one unit of the base good and one unit of the add-on, which can only be bought from the same firm. All firms produce the base good at identical costs normalised to zero, but differ in the add-on production costs.[3] The constant marginal costs for producing the add-on by firm i is c_i. Firms are ordered such that $c_1 < c_2 < ... < c_n$.

All consumers observe base-good prices p_i. A firm's add-on price, $\hat{p}_i$, however, can only be observed if it is advertised. There are myopic and sophisticated consumers. Sophisticated consumers are aware of the add-on and form beliefs about add-on prices if they are shrouded. Myopic consumers are unaware of the add-on and ignore add-on prices. Initially, the share of myopic (sophisticated) consumers is α $(1 - \alpha)$, where $\alpha \in (0, 1)$.

Firms can unshroud (advertise) add-on information which has two consequences. First, if a firm unshrouds, sophisticated consumers learn the add-on price charged by this firm. Second, by unshrouding some myopic con-

[3] The model can easily be extended to also cover cost asymmetry for the base product, however, this has no impact on unshrouding incentives.

sumers are educated and act like sophisticated consumers. As in Wenzel (2014), it is assumed that the fraction of consumers that become sophisticated depends on the number of unshrouding firms. To be concrete, suppose that for each each unshrouding firm, the number of myopic consumers is reduced by a fraction $\lambda \in (0, 1)$. Thus, if k firms unshroud, a fraction $\alpha(1-\lambda)^k$ of consumers remains myopic.[4]

There is a maximal price of $\bar{p}$ that firms may charge for the add-on. Moreover, sophisticated consumers can avoid the add-on purchase by using an outside option at a cost e in stage 2.

To model competition in the base-good market we employ a logit model of product differentiation (e.g., Anderson and de Palma, 2001). Firms offer differentiated base-good products, and the preferences of a myopic consumer j, only aware of the base good, buying from firm i can be described by

$$u_{ij} = v - p_i + \epsilon_{ij}. \tag{1}$$

The match value ϵ_{ij} is the realisation of a random variable (iid across firms and consumers) which is double exponentially distributed with mean zero and standard deviation μ, where μ can be interpreted as the degree of product differentiation. Myopic consumers pick the firm that offers the best combination of base-good price and match value. Then, the expected demand from myopic consumers of firm i is

$$D_i^m = \frac{\exp[(-p_i)/\mu]}{\sum_{k=1}^{n} \exp[(-p_k)/\mu]}. \tag{2}$$

Sophisticated consumers are aware of the add-on and, when selecting the base good, take add-on prices into account. Expected demand from sophisticated consumers is

$$D_i^s = \frac{\exp[(-p_i - E(\hat{p}_i))/\mu]}{\sum_{k=1}^{n} \exp[(-p_k - E(\hat{p}_k))/\mu]}. \tag{3}$$

We study the following three-stage game:

[4]One reason for this modification is that it is more likely that a myopic consumer picks up add-on information if more firms unshroud by sending out advertising messages. A more general setup (however, with symmetric firms) without assuming a functional form is studied in Wenzel (2014).

- In stage 1, firms set prices for the base good, p_i, and for the add-on, $\hat{p}_i$, and decide whether to unshroud add-on information.
- In stage 2, consumers decide from which firm to buy the base good. Sophisticated consumers and educated, myopic consumers decide whether to substitute away from the add-on.
- In stage 3, myopic consumers buy the add-on. Sophisticated consumers buy the add-on only if they have not substituted away.

3 Results

This section provides the equilibrium of the game. I focus on equilibria in pure strategies. We start with a preliminary finding:

Lemma 1. In any equilibrium, a shrouding firm chooses $\hat{p} = \bar{p}$ and an unshrouding firm chooses $\hat{p} = e$.

This property also holds in Gabaix and Laibson (2006). Add-on prices are high if shrouded and low if unshrouded. This means that sophisticated consumers always pay e for the add-on (via substitution or buying at $\hat{p} = e$). This also implies $D_i^s = D_i^m = D_i$.

Let us next establish that firms with lower add-on costs have larger unshrouding incentives than firms with higher add-on costs. Suppose that a firm decides to shroud the add-on, in which case it sets $\hat{p} = \bar{p}$ and sells the add-on only to myopic consumers. With $\widehat{\alpha}$ myopic consumers firm i earns profit of

$$\Pi_i = D_i(p_i, p_{-i})[p_i + \widehat{\alpha}(\bar{p} - c_i)]. \tag{4}$$

If firm i decides to unshroud, it sets $\hat{p} = e$ and sells the add-on to both types of consumers earning

$$\Pi_i = D_i(p_i, p_{-i})[p_i + (e - c_i)]. \tag{5}$$

Define $\overline{\alpha}_i = \frac{e-c_i}{\bar{p}-c_i}$. Comparison of (4) and (5) shows that firm i decides to unshroud iff $\alpha < \overline{\alpha}_i$. Note that $\frac{\partial \overline{\alpha}_i}{\partial c_i} < 0$, which implies:

Lemma 2. Firms with lower add-on costs have larger incentives to unshroud add-on information.

The intuition behind this finding is that firms with low cost benefit to a larger extent from increased add-on demand resulting from unshrouding due to a higher add-on margin. This lemma will be helpful in establishing the existence of partial shrouding equilibria.

As in GL there exist symmetric equilibria where all firms shroud / unshroud:

Proposition 1. i) Let $\bar{\alpha} = \frac{e-c_1}{\bar{p}-c_i}$. Then, a shrouding equilibrium exists if $\alpha > \bar{\alpha}$. All firms shroud and set $\hat{p} = \bar{p}$.

ii) Let $\underline{\alpha} = \frac{e-c_n}{(\bar{p}-c_n)(1-\lambda)^{n-1}}$. Then, an unshrouding equilibrium exists if $\alpha < \underline{\alpha}$. All firms unshroud and set $\hat{p} = e$.

This mirrors the structure in GL. Part i) shows that if the number of myopic consumers is sufficiently large no firm unshrouds in equilibrium. Part ii) demonstrates that for a low number of myopic consumers all firms unshroud.

Unilke GL, with asymmetric add-on productivity also partial shrouding equilibria exist:

Proposition 2. Suppose $\lambda < 1 - \frac{(e-c_{k+1})/(\bar{p}-c_{k+1})}{(e-c_k)/(\bar{p}-c_k)}$. Then, there exists an α such that $\frac{e-c_k}{(\bar{p}-c_k)(1-\lambda)^{k-1}} > \alpha > \frac{e-c_{k+1}}{(\bar{p}-c_{k+1})(1-\lambda)^k}$, and a partial shrouding equilibrium exists. Low-cost firms (Firms 1,...,k) unshroud and high-cost firms (Firms $k+1$,...,n) shroud. Unshrouding firms set $\hat{p} = e$ and shrouding firms set $\hat{p} = \bar{p}$.

Prices of the base good and profits of an unshrouding / shrouding firm are implicitly given by:

$$p_u^* + (e - c_u) = \frac{\mu}{1 - D_u(p_u^*, p_{-u}^*)}; \qquad \Pi_u^* = p_u^* + (e - c_u) - \mu \tag{6}$$

$$p_s^* + \alpha(1-\mu)^k(\bar{p}-c_s) = \frac{\mu}{1 - D_s(p_s^*, p_{-s}^*)}; \qquad \Pi_s^* = p_s^* + \alpha(1-\mu)^k(\bar{p}-c_s) - \mu \tag{7}$$

Proposition 2 provides conditions for the existence of partial shrouding equilibria where only a subset of firms shrouds. The proposition delivers a selection result: Firms with low add-on production cost unshroud while firms with high add-on production cost shroud.

There are two points worth emphasising. Firstly, partial shrouding equilibria arise only for intermediate levels of myopic consumers $\frac{e-c_k}{(\bar{p}-c_k)(1-\lambda)^{k-1}} > \alpha > \frac{e-c_{k+1}}{(\bar{p}-c_{k+1})(1-\lambda)^k}$. For higher (lower) levels of myopic consumers, the more (less) efficient firms would have an incentive to shroud (unshroud). Secondly, the existence of partial shrouding equilibria depend on the degree of cost asymmetry. With identical firms partial shrouding equilibria do not exist as the condition $\lambda < 1 - \frac{(e-c_{k+1})/(\bar{p}-c_{k+1})}{(e-c_k)/(\bar{p}-c_k)}$ is not satisfied for $c_{k+1} = c_k$. Indeed, partial shrouding equilibria are more likely to arise if the cost asymmetry is rather large.

Finally, let us explore the differences between shrouding and unshrouding firms regarding base-good prices and market shares in a partial shrouding equilibrium:

Proposition 3. Suppose there exists a partial shrouding equilibrium. Then, any unshrouding firms has a lower base-good price and a larger market share than any shrouding firm. Moreover, any unshrouding firm has a higher average markup per consumer than any shrouding firm.

In a partial shrouding equilibrium unshrouding firms behave more aggressively by charging lower base-good prices and obtaining higher market shares. This result is somewhat unexpected, as one would usually suspect shrouding firms, that charge high add-on prices, to set lower base-good prices. Here, however, this intuition is overturned due to our selection result. Unshrouding firms, though charging a low add-on price, have nevertheless higher add-on profits due to lower cost. This makes unshrouding firms compete more aggressively for more market share.

A Appendix

Derivations of Lemma 1

Suppose there exists an equilibrium in which firm i shrouds. Then, the add-on price is not observable and as demand of the add-on is inelastic, then firm has for any given price expectation an incentive to increase the price to the upper limit $\bar{p}$. Hence, any price below $\bar{p}$ is not credible. Sophisticated consumers expect $\bar{p}$ and avoid add-on consumption. Hence, $\hat{p} = \bar{p}$ if the firm shrouds in equilibrium.

Suppose there exists an equilibrium in which firm i unshrouds. Then, all consumers observe the add-on price. A price below e is not profit-maximising as price could be increased up to e without losing demand. Charging any price above e cannot be part of an unshrouding equilibrium. As with price above e a firm would only sell to myopic consumers in which case it it would be optimal to shroud as to maximize the number of myopic consumers. Hence, $\hat{p} = e$ if the firm unshrouds in equilibrium.

Derivations of Proposition 1

The proof follows GL. i) Suppose that $\alpha > \frac{e-c_1}{\bar{p}-c_1}$. By Lemma 2 we only have to check whether Firm 1 has an incentive to deviate from shrouding.

Suppose that all firms except Firm 1 shroud the add-on. If Firm 1 shrouds it optimally sets $\hat{p} = \bar{p}$ earning $\Pi_1^s = \alpha D_1^m[p_1 + (\bar{p} - c_1)] + (1-\alpha) D_1^s[p_1] = D_1[p_1 + \alpha(\bar{p} - c_1)]$. If Firm 1 unshrouds it optimally sets $\hat{p} = e$ earning $\Pi_1^u = \alpha D_1^m[p_1 + (e - c_1)] + (1 - \alpha) D_1^s[p_1 + (e - c_1)] = D_1[p_1 + (e - c_1)]$. The comparison reveals that shrouding leads to higher profits if $\alpha > \frac{e-c_1}{\bar{p}-c_1}$.

ii) Suppose that $\alpha < \frac{e-c_n}{(\bar{p}-c_n)(1-\lambda)^{n-1}}$. By Lemma 2 we only have to check whether Firm n has an incentive to deviate from unshrouding.

Suppose that all firms except Firm n shroud the add-on. If Firm n shrouds it optimally sets $\hat{p} = \bar{p}$ earning $\Pi_n^s = D_n[p_n + \alpha(1-\lambda)^{n-1}(\bar{p} - c_n)]$. If Firm n unshrouds it optimally sets $\hat{p} = e$ earning $\Pi_n^u = D_n[p_n + (e - c_n)]$. Comparison reveals that unshrouding leads to higher profits if $\alpha < \frac{e-c_n}{(\bar{p}-c_n)(1-\lambda)^{n-1}}$.

Derivations of Proposition 2

Suppose $\lambda < 1 - \frac{\frac{e-c_{k+1}}{\bar{p}-c_{k+1}}}{\frac{e-c_k}{\bar{p}-c_k}}$. This implies that there exists an α such that $\frac{e-c_k}{(\bar{p}-c_k)(1-\lambda)^{k-1}} > \alpha > \frac{e-c_{k+1}}{(\bar{p}-c_{k+1})(1-\lambda)^k}$. We show that a partial shrouding equilibrium exists such that low-cost firms (Firms 1,...,k) unshroud and high-cost firms (Firms $k+1$,...,n) shroud.

By Lemma 2 it suffices to show that Firm k ($k+1$) has no incentive to deviate from unshrouding (shrouding). Firm k prefers to unshroud if $\alpha < (e-c_k)/(\bar{p}-c_k)(1-\lambda)^{k-1}$ and firm $k+1$ prefers to shroud if $\alpha > (e-c_{k+1})/(\bar{p}-c_{k+1})(1-\lambda)^k$. Hence, for $\frac{e-c_k}{(\bar{p}-c_k)(1-\lambda)^{k-1}} > \alpha > \frac{e-c_{k+1}}{(\bar{p}-c_{k+1})(1-\lambda)^k}$ there exists a partial shrouding equilibrium. Base-good prices and firm profits can be derived from the FOC.

We note that no partial shrouding equilibrium without the selection property exists. This is shown by contradiction. Suppose there exists an equilibrium where firm k shrouds and firm h unshrouds where and $c_k < c_h$. The total number of unshrouding firms is g. For firm k shrouding is optimal if $\alpha > (e-c_k)/(\bar{p}-c_k)(1-\lambda)^g$ and for firm $k+h$ unshrouding is optimal if $\alpha < (e-c_h)/(\bar{p}-c_h)(1-\lambda)^{g-1}$. Hence, such an equilibrium can only exist if there is an α such that both conditions exist. However, $(e-c_h)/(\bar{p}-c_h)(1-\lambda)^{g-1} > (e-c_k)/(\bar{p}-c_k)(1-\lambda)^g \Leftrightarrow c_k > c_h$ which is a contradiction and, hence, no such equilibrium exists.

Derivations of Proposition 3

Let b_i be the per-consumer add-on revenues: $b_u = \alpha(e-c_u)$ for an unshrouding firm; $b_s = \alpha(\bar{p}-c_s)$ for a shrouding firm. Note that due to selection result in equilibrium, $b_u > b_s$. Logit demand implies $D_u > D_s \Leftrightarrow p_u < p_s$. From the FOC we have $D_u > D_s \Leftrightarrow p_s + b_s > p_u + b_u$. Taken together, it follows that $D_u > D_s \Leftrightarrow b_u > b_s$. Hence, any unshrouding firm has a lower base-good price and a higher market share than any shrouding firm.

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