2012- 14 / April 2012

Document de travail

ASYMMETRIC SWITCHING COSTS CAN IMPROVE THE PREDICTIVE POWER OF SHY'S MODEL

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Abstract

Economists Oz Shy introduced the definition of *undercut-proof property* ("UPP") prices in a model of Bertrand competition involving loyal consumers ('A quick-and-easy method for estimating switching costs', *International Journal of Industrial Organization*, Vol. 20, pp. 71-87, 2002). Shy's seminal paper allows applied researchers to measure the switching costs faced by locked-in consumers. Although there is increasing interest in demonstrating consumer inertia in retail markets opened up to competition, Shy's approach has not received much attention. The present paper shows that the UPP's lack of appeal in this context stems from a strong assumption of identical switching costs in the theoretical model, whereas real data are more likely to reveal asymmetric values for these costs. We revisit the UPP by considering asymmetric switching costs straight from the theoretical model. Doing so enables us to show that more rigorous conditions relating the values of switching costs to market shares are necessary in order for UPP prices to be valid predictions of these costs, which consequently increases the predictive power of Shy's model. This improvement is illustrated with two examples borrowed from Shy's paper.

JEL Codes: D43, D83.

Keywords: Price competition, Switching costs, Undercut-Proof Property.

1. Introduction

In the present paper, I revisit the model of imperfect price competition, suggested in Morgan and Shy (2000) then Shy (2002b), which allows the measurement of consumer switching costs as between two or more brands. In the case of two firms, each sets its price subject to the constraint that the other will not find it profitable to undercut that price and grab all its customers. Shy (2002a, p. 75) suggests that those prices satisfy a property that he calls the Undercut-Proof Property ("UPP"). At equilibrium, UPP prices are a function of firms' market shares and unobservable switching costs. Using observations based only on prices and market shares, these variables can be mapped into two levels of switching costs (one for each brand).

Though the method is quick and easy as suggested by its inventor Shy, the UPP has not very received much attention. In a laboratory experiment designed to investigate spatial price competition, Orzen and Sefton (2008) and Peters and Stroble (2009) find weak evidence in support of the UPP as a solution concept in favour of other refinements of the Bertrand-Nash paradigm. There are at least two reasons for not favouring one solution concept over another. First, switching costs are neither restricted to being equal nor to taking positive values; a situation that is not allowed by the above authors who consider the original UPP solution concept. Second, Morgan and Shy (2000) then Shy (2002a, 2002b) consider switching costs as a parameter that is exogenous to the firm whilst endogenous to the modeller, whereas it is set at the beginning of the models tested in the aforementioned laboratory experiments. This endogenous nature of consumer switching costs in Shy's model is part of what seems to make the UPP so difficult for many to accept.[1] Unlike travel costs that can be calculated *ex-ante* the economic transaction, the whole value of switching costs as modelled by Shy can only be calculated *ex-post,* that is to say, given prices and market shares.

Rather than attempt to further situate Shy's model of price competition with loyal consumers relative to other theoretical solutions, I shall instead try to improve its predictive power. I revisit the UPP in the two-firm case by giving more precise conditions for the range of market shares and switching costs under which prices satisfy the UPP. Unlike Morgan and Shy (2000), and Shy (2002b), we assume in the theoretical model underlying the UPP that consumers may have asymmetric switching costs. One implication is that the theoretical prediction made by these authors to the effect that larger firms charge lower prices (Morgan and Shy, 2000, p. 1) becomes a particular case. Furthermore, our model accommodates negative switching costs by interpreting them as net rather than gross values as suggested

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1. It is worth noting that in the literature, the meaning of "endogenous switching costs" differs from that which we use here. Switching costs are considered as endogenous to a firm when it creates them (e.g., the impossibility of transferring one's local phone number from the incumbent to a competing carrier). In the present paper, "endogenous" is used with respect to the modelling practice. In Shy's model, switching costs are a function of the firms' prices and market shares. In Orzen and Sefton, prices and market shares are functions of the switching cost.

in Green's 2000 working paper (see Krafft and Salies, 2008 with respect to Green's contribution). Shy's definition (2002a, pages 189-191) of the undercut-proof property solution concept assumes symmetric costs, however these costs become asymmetric values when he applies the UPP for measuring switching costs from real data. This improvement in the predictive power of Shy's model should contribute to making the UPP more able to explain the data in future laboratory experiments.

2. UPP with real and asymmetric switching costs

Two firms *a* and *b* sell a homogenous product to *N* consumers. There is a share $\alpha > 0$ of brand *a* oriented consumers and $1-\alpha > 0$ of brand *b* oriented consumers. Firm *a*'s customers perceive a net cost s_{ab} of switching to firm *b* while firm's *b* customers perceive a net cost s_{ba} of switching to *a*. The utility functions of each type of consumer are:

$$u_a = \begin{cases} U_a - T_a & \text{if staying with brand } a \\ U_b - T_b - s_{ab} & \text{if switching to brand } b \end{cases} \tag{1a}$$

$$u_b = \begin{cases} U_b - T_b & \text{if staying with brand } b \\ U_a - T_a - s_{ba} & \text{if switching to brand } a \end{cases} \tag{1b}$$

where U_i denotes gross utility for each type of consumer. T_a is firm *a*'s price and T_b is firm *b*'s price. Negative switching costs may be defined as follows: let s be the 'gross' level of switching costs common to both types of consumers, and denote $U_b - U_a$ as the value that firm *a*'s customers attach to buying from firm *b*. Let $v_b \equiv U_b - U_a$, then s_{ab} and s_{ba} are $s - v_b$ and $s - v_a$, respectively where $v_a \equiv -v_b$. Let n_a and $n_b \equiv 1 - n_a$ denote the shares of customers buying brand *a* and *b*, respectively. These numbers depend on prices and switching behaviours of both types of customers:

$$n_\alpha = \begin{cases} 0 & \text{if} \quad T_a > T_b + s_{ab} \\ \alpha & \text{if} \quad T_b - s_{ba} \le T_a \le T_b + s_{ab} \\ 1 & \text{if} \quad T_a < T_b - s_{ba} \end{cases} \tag{2a}$$

$$n_\beta = \begin{cases} 0 & \text{if} \quad T_b > T_a + s_{ba} \\ 1-\alpha & \text{if} \quad T_a - s_{ab} \le T_b \le T_a + s_{ba} \\ 1 & \text{if} \quad T_b < T_a - s_{ab} \end{cases} \tag{2b}$$

The following definition generalises Shy's definition (2002, p. 75) of UPP prices and market shares to the situation where the two types of consumers have asymmetric net switching costs.

Proposition 1. *Prices* $T_a^U = \dfrac{s_{ab} + n_\beta s_{ba}}{1 - n_\alpha n_\beta}$, $T_b^U = \dfrac{s_{ba} + n_\alpha s_{ab}}{1 - n_\alpha n_\beta}$, *and market shares* $n_\alpha = \alpha$, $n_\beta = 1 - \alpha$ *satisfy the UPP if* $\min\{0, -(1-\alpha)s_{ba}\} < s_{ab}$, *where* $s_{ba} \in IR$.

Assume the larger firm is a ($\alpha \geq 1-\alpha$ *). If,*

(a) $s_{ba}>0$ *and* $-(1-\alpha)s_{ba}<s_{ab}<\dfrac{\alpha}{1-\alpha}s_{ba}$ *then a charges the lower price.*

(b) $s_{ba}>0$ *and* $s_{ab}>\dfrac{\alpha}{1-\alpha}s_{ba}$ *then a charges the higher price.*

(c) $s_{ba}<0$ *and* $s_{ab} \geq 0$ *then a charges the higher price.*

Assume firms share the market equally. If,

(d) $s_{ab}>s_{ba}$ *then a charges the higher price.*

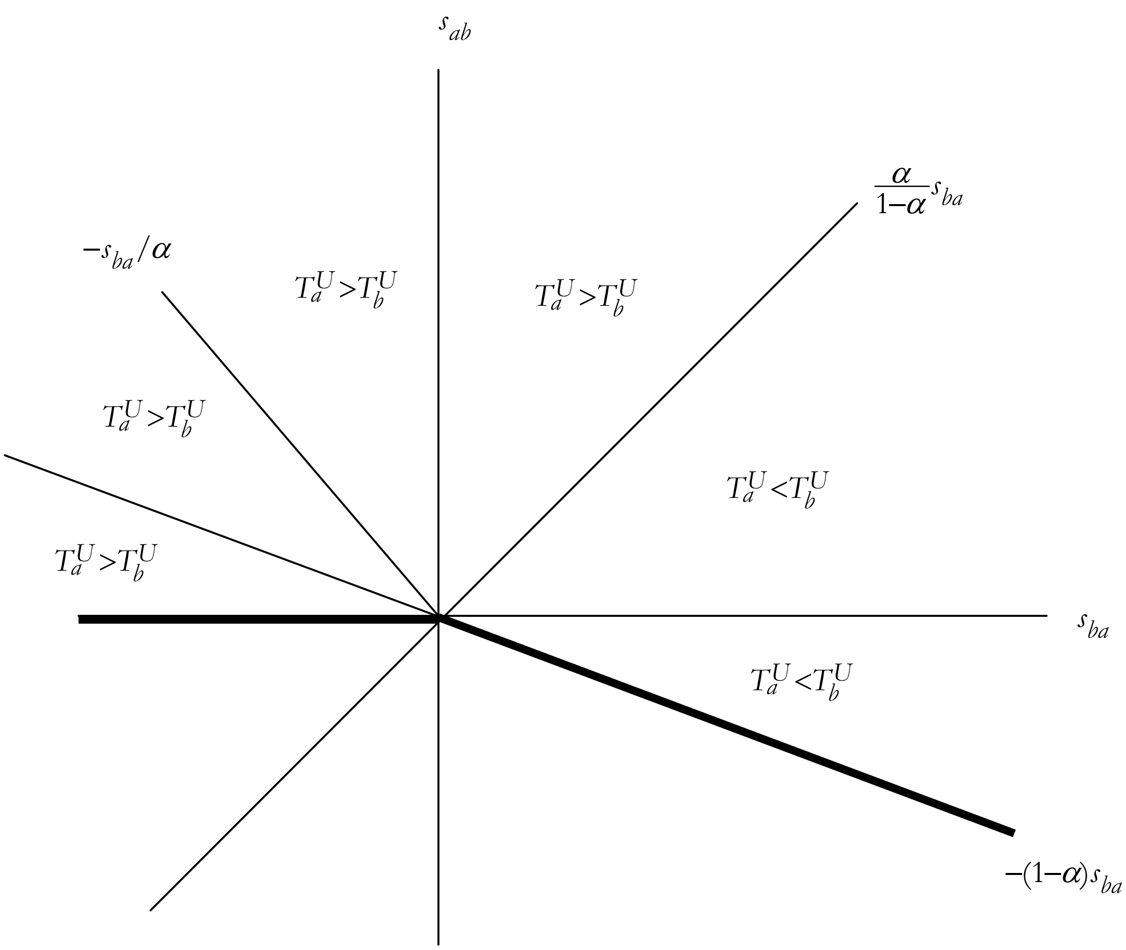
Proof: see **Appendix**.

Note that if $s_{ba}<0$ then s_{ab} must be strictly greater than zero for UPP prices to exist. In all cases where prices satisfy the UPP, switching costs are $s_{ab} = T_a^U - (1-\alpha)T_b^U$ and $s_{ba} = T_b^U - \alpha T_a^U$. Prices T_a^U and T_b^U become simplified so as to effectively assimilate to those in Shy (2002, p. 75) when $s_{ab} \equiv s_{ba}$. In this case (under equal switching costs) Shy's model (2002b) predicts that the larger firm charges the lower price. Indeed it is possible to write $\text{sgn}(T_a^U - T_b^U) = \text{sgn}(1-2\alpha)$ [see (*iii*) in the proof of Proposition 1 in the Appendix]. We draw the reader's attention to the fact that our assertion is different to and stronger than that actually stated by the author: "… under the UPP, the firm with the higher market share charges a lower price …" (Shy, 2002b, p. 76, footnote 4). In fact, Shy's assertion is true under stronger conditions relating market shares to switching costs of which one is that switching costs are identical.

Proposition 1 demonstrates that the larger firm may also charge the higher price thus showing that the direction of the relation between price differentials and market shares depends on the relative levels of switching costs. Accordingly, the assertion that "…equilibrium prices of brands monotonically diverge when the brands become more differentiated…" (Morgan and Shy, 2000, p. 1) may be restated as: holding s_{ba} (respectively s_{ab}) constant, equilibrium prices of brands monotonically diverge when s_{ab} increases (respectively s_{ba} decreases).

More critically, Proposition 1 shows that more rigorous conditions relating the values of switching costs to market shares are necessary in order for UPP prices to be valid predictions of these costs, given actual data on prices and market shares. This contrasts with Morgan and Shy (2000, p. 2) who found that an UPE exists for any value of the switching cost. It is also now clear that these authors' assertion that the larger firm charges the lower price is true not only under equal switching costs but also in a larger region of the values for s_{ab} and s_{ba}. Our refinement of Shy's model (2002a, 2002b) makes it of greater interest to studies of firms' pricing behaviour in markets where consumers face switching costs. In fact, real data tend to show a positive correlation coefficient between prices and market shares and a negative net cost of switching from small firms (see e.g. Krafft and Salies, 2008 and the applications in Shy, 2002b). Our generalisation widens its application to include situations such as where the larger firm charges the higher price and the smaller firm serves customers with the higher switching costs. The region of the values for s_{ab} and s_{ba} compatible with UPP prices is given in Figure 1 as well as the sub-regions where $T_a^U > T_b^U$ and those where $T_a^U < T_b^U$. Any values for s_{ab} and s_{ba} below the thick line are not compatible with the existence of UPP prices.

Figure 1: UPP prices given the region of the values for s_{ab} and s_{ba}.



3. Comment on Shy's results (2002b) in the banking and cellular phone markets

Once the applied researcher has calculated switching costs for customers of two competing firms (note that the model can easily be applied for measuring consumer switching costs between sets of more than two competing firms; see Krafft and Salies, 2008; Shy, 2002b), it is recommended that he or she identify whether these values are compatible with one of three situations (a)–(c) described in Proposition 1.[2]

For example, in the case of the Israeli cellular phone market, Shy (2002b, Table 1) finds that the larger firm has consumers with lower switching costs and who also pay the lower price. Since the existence of UPP prices in Shy's model is demonstrated where switching costs are identical, this case is actually not predicted by the model. Point (a) of Proposition 1 in the present paper remedies that problem since it shows that the larger firm may even have consumers with negative switching costs.

All measures of switching costs given by Shy (2002b) when applying his model to the Finnish banking industry in 1997 are also supported by our proposition. In particular, the measure of the cost of switching from bank 3 to the smallest bank ($464) is no longer an exception in the present paper. Consider bank 3 as firm *a* and the smallest bank (bank 4) as firm *b*. From Table 2 of Shy (2002b, p. 80) we can calculate the switching cost in the opposite direction (from bank *b* to *a*). We obtain ≈ 4.64. Since s_{ab} = 464 is greater than $(\alpha/(1-\alpha))s_{ba}$ = (4 051 852 / 952 093) × 4.64 = 19.7. This case is predicted by (b) in our proposition, while the negative value of switching costs for consumers willing to switch to the largest bank (bank 1 in the Table) is predicted by point (c).

4. Conclusion and discussion

This paper increases the predictive power of the undercut-proof property (UPP) introduced by Shy (2002b). We show that more rigorous conditions relating the values of switching costs to market shares are necessary in order for UPP prices to be valid predictions of these costs. The situation where the larger firm charges a higher price is taken into account, making the model more realistic. A negative consumer cost for a switch to the smallest competitor is also predicted by the model, a situation which is common in empirical applications. This improvement in the predictive power of Shy's model should contribute to making the UPP more able to explain the data in future laboratory experiments. We also expect that it will motivate more applied researchers to use the UPP to the measurement of switching costs in markets with apparent consumer inertia. A next and quite important step in this research could consist of providing a probabilistic framework for testing a hypothesis on the values found for switching costs where some of these values appear very similar.

Acknowledgements

I am grateful to Adam Cutforth for assistance in finalizing the text of this paper. Any remaining errors are my entire responsibility.

2. Situation (d) of equal market shares is not very likely to occur.

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Appendix

Proof of **Proposition 1**: for given T_b and n_β, firm *a* chooses the highest price T_a subject to

$$\pi_b = n_\beta T_b \geq N(T_a - s_{ab}) \tag{A1}$$

Simultaneously, for given T_a and n_α, firm *b* chooses the highest price T_b subject to

$$\pi_a = n_\alpha T_a \geq N(T_b - s_{ba}) \tag{A2}$$

Let's find the UPP prices and associated market shares. It can be shown that (A1) and (A2) hold with equality. This system has a solution in prices if $N^2 - n_\alpha n_\beta > 0$. We obtain,

$$T_a = \frac{N(Ns_{ab} + n_\beta s_{ba})}{N^2 - n_\alpha n_\beta},\ T_b = \frac{N(Ns_{ba} + n_\alpha s_{ab})}{N^2 - n_\alpha n_\beta} \tag{A3}$$

As consumers spread across firms, there are three possible cases for (n_α^U, n_β^U). (*i*): $(0, N)$; (*ii*): $(N, 0)$; (*iii*): (N_α, N_β). Subtract *b*'s price from *a*'s ($T_a - T_b = \frac{N(n_\beta s_{ab} - n_\alpha s_{ba})}{N^2 - n_\alpha n_\beta}$). Cases (*i*) and (*ii*) are not equilibriums. From (2a), (2b), $T_a - T_b > s_{ab}$ is associated with $(n_\alpha, n_\beta) = (0, N)$ whereas price differential at equilibrium from (A3) is $T_a - T_b = s_{ab}$. Similarly, $T_a - T_b < -s_{ba}$ is associated with $(n_\alpha, n_\beta) = (N, 0)$ whereas price differential is $T_a^U - T_b^U = -s_{ba}$. In case (*iii*), price differential is $T_a^U - T_b^U = \frac{N(N_\beta s_{ab} - N_\alpha s_{ba})}{N^2 - N_\alpha N_\beta}$. The relative values of s_{ba} and s_{ab} determine several equilibrium. Denote δ as $(N_\alpha - N_\beta)/N_\beta$.

Under case (*iii*), prices satisfy the UPP if $-s_{ba} \leq T_a - T_b \leq s_{ab}$, i.e.

$$-s_{ba} \leq \frac{N(N_\beta s_{ab} - N_\alpha s_{ba})}{N^2 - N_\alpha N_\beta} \leq s_{ab} \tag{A4}$$

This double inequality imposes some restrictions on the relative values of markets shares and switching costs. Replace $N_\beta s_{ab}$ with $N_\beta s_{ab} \pm N^{-1}(N^2 - N_\alpha N_\beta)s_{ab}$ then price differential is:

$$s_{ab} - \frac{N_\alpha(N_\alpha s_{ab} + N s_{ba})}{N^2 - N_\alpha N_\beta} \tag{A5}$$

Similarly, if we replace $N_\alpha s_{ba}$ with $N_\alpha s_{ba} \pm N^{-1}(N^2 - N_\alpha N_\beta)s_{ba}$ we obtain

$$-s_{ba} + \frac{N_\beta(N_\beta s_{ba} + N s_{ab})}{N^2 - N_\alpha N_\beta} \tag{A6}$$

If switching costs are positive, (A4) is easy to verify. Switching costs can however be negative, which requires the constraints that the second terms in both (A5) and (A6) be simultaneously greater or equal to zero. This leads us to the relationship between market shares and switching costs stated in **Proposition 1**. We finally mention two particular cases which are easy to demonstrate: $s_{ab} = (1+\delta)s_{ba}$ and $\delta \equiv 0$ (firms share the market equally). In the first case, firms charge the same price. In the second case, $T_a - T_b = \frac{2}{3}(s_{ab} - s_{ba})$.