

A quick-and-easy method for estimating switching costs

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Abstract

I develop and test a method for a quick-and-easy calculation of consumer switching costs among brands in a given industry. The theory developed and tested here maps observed brands' prices and market shares onto the switching costs which deter a consumer of a specific brand from switching to any other competing brand. Then, I demonstrate how users' switching costs can be directly calculated in two different industries: (a) the Israeli cellular phone market, and (b) the Finnish market for bank deposits. This calculation method can be used to calculate switching costs in a wide variety of other industries, such as airlines, health services, computers, software, telecommunications, and more. © 2002 Elsevier Science B.V. All rights reserved.

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1. Introduction

In many markets consumers face substantial costs of switching from a product (or a service) to a competing product. Such markets for products or services are generally characterized by consumer lock-in where it is observed that consumers repeatedly purchase the same brand even after competing brands become cheaper. One important consequence of having consumer lock-in is the ability of firms to

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charge prices above marginal costs. The main source of consumer lock-in is consumer switching costs, generated by human and physical capital each consumer invests upon purchasing a particular brand operating on a specific standard which may be incompatible with the standards embedded in the competing brands. Examples include purchasing of computers using a particular operating system, cellular phone using a wide variety of incompatible digital and analog standards, and video and audio recorders. Consumer switching costs prevail also in services, for example, in the banking industry consumers bear high costs of switching from one bank to another, high costs of switching among airline companies (losing frequent-flyer benefits), and high cost of switching among schools and health plans (HMOs).

Theoretically, the possibility that consumer switching costs confer market power on firms have been demonstrated by von Weizsäcker (1984), Klemperer (1987a,b), and others (see Tarkka (1995) for the banking industry). However, as far as empirical research is concerned, there is very little theoretical knowledge of how to estimate switching costs precisely because switching costs are not observed by the economist. The reason why switching costs are not observed is that they are partly consumer-specific, reflecting the individual's human capital needed for switching among systems, and are therefore treated as a utility loss which cannot be directly calculated from any data. Since prices and market shares are relatively easily observed, it is important to develop a simple theory which connects the observed prices and market shares with the unobserved switching costs, which is precisely the goal of this paper.

The main contribution of this paper is the construction of a simple calculation method of an unobserved variable which is the switching costs of a brand user. The price/fee competition model developed in this paper enables us to solve for the switching cost as a function of prices/fees and market shares only. Using this method, I fit the data from two different industries: the Israeli cellular phone industry and the Finnish market for bank deposits and get some estimates of the switching cost of the corresponding consumers.

The framework developed and tested in this paper relies on the assumption that firms, which are engaged in price competition in a given industry, recognize consumer switching costs and therefore maximize prices subject to a constraint that no other firm will find it profitable to undercut its price in order to 'subsidize' its consumers' switching costs. As I show below, this behavior of firms is also a property (or a consequence) of the commonly-used Nash–Bertrand equilibrium concept. I demonstrate that this property is extremely useful in price determination in industries characterized by switching costs. Then, using these prices I solve for the reduced form and calculate brand-specific switching costs as functions of observed prices and market shares.

Despite the vast theoretical literature on consumer switching costs, empirical works are hard to find. Greenstein (1993) looks at switching costs in mainframe computer purchases using data on U.S. federal government procurement. Breuhan

(1997) conducts a comprehensive econometric study of switching costs associated with the Windows and DOS operating systems for personal computers. Sharpe (1997) analyzes the effects of switching costs on fees in the bank deposit market. Kim et al. (1999) estimate consumer switching costs in the Norwegian market for loans. Borenstein (1991) studies the market for gasoline and Knittel (1997) the market for long-distance phone calls. Finally, Elzinga and Mills (1998) estimate switching costs in the wholesale distribution of cigarettes. The present paper differs from all the above in one important aspect: The approach here calculates switching costs without using any econometrics. Instead, the estimation method for switching costs relies on direct calculations from observed prices and market shares.

The paper is organized as follows. Section 2 develops the basic framework of how two firms or stores price their products and services in the presence of consumer switching costs. Section 3 extends the model to more than two firms and prepares the functional form to be tested later on using actual data. Section 4 provides actual data from the Israeli cellular phone market from which, using the analytic framework, we calculate the true average consumer switching costs. Section 5 provides actual data from the Finnish market for bank deposits from which we calculate the switching costs of account holders. Section 6 extends the model to allow for downward-sloping demand functions. Section 7 concludes with a discussion on the problem of interpreting switching costs as a stock variable.

2. A model consumer switching costs

Consider a market with two firms called firm *A* and firm *B* producing brand *A* and brand *B* respectively. Consumers are distributed between the firms so that initially N_A consumers have already purchased brand *A* (type α consumers), and N_B consumers have already purchased brand *B* (type β consumers). Let p_A and p_B denote prices charged by the firms, respectively. Also, let $S > 0$ denote the cost of switching from one brand to another. Let U_α denote the utility of a consumer who has purchased brand *A*, and U_β the utility of a consumer who has purchased brand *B*. Altogether, the utility function of each consumer type derived from the next purchase is given by

$$\begin{aligned}
 U_\alpha &\stackrel{\text{def}}{=} \begin{cases} -p_A & \text{staying with brand A} \\ -p_B - S & \text{switching to brand B} \end{cases} \quad \text{and} \\
 U_\beta &\stackrel{\text{def}}{=} \begin{cases} -p_A - S & \text{switching to brand A} \\ -p_B & \text{staying with brand B.} \end{cases} \quad (1)
 \end{aligned}$$

Let n_A denote the (endogenously determined) number of brand *A* buyers (on their next purchase), and n_B denote the number of brand *B* buyers (on their next purchase). Then, (1) implies that

$$\begin{aligned}
 n_A &= \begin{cases} 0 & \text{if } p_A > p_B + S \\ N_A & \text{if } p_B - S \leq p_A \leq p_B + S, \\ N_A + N_B & \text{if } p_A < p_B - S \end{cases} \\
 n_B &= \begin{cases} 0 & \text{if } p_B > p_A + S \\ N_B & \text{if } p_A - S \leq p_B \leq p_A + S \\ N_A + N_B & \text{if } p_B < p_A - S. \end{cases} \quad (2)
 \end{aligned}$$

Assume that firms' production costs are zero. Thus, the profit of each firm, as a function of prices are

$$\pi_A(p_A, p_B) = p_A n_A \quad \text{and} \quad \pi_B(p_A, p_B) = p_B n_B, \quad (3)$$

where n_A and n_B are given in (2).

The undercut-proof property of a Nash–Bertrand equilibrium

A Nash–Bertrand equilibrium is the nonnegative pair of prices $\langle p_A^N, p_B^N \rangle$ such that, for a given p_B^N , firm A chooses p_A^N to maximize π_A and, for a given p_A^N , firm B chooses p_B^N to maximize π_B . Unfortunately, a Nash–Bertrand equilibrium in pure prices does not exist. For a complete proof see Shy (1996, Ch. 7). The proof goes as follows. Firm A can set a maximal price $p_A = p_B + S$ without losing any of its N_A customers. Similarly, firm B can raise p_B so that $p_B = p_A + S$. Clearly, these two equations are inconsistent, so a unilateral deviation occurs at any pair of $\langle p_A, p_B \rangle$.¹

Despite the fact that a Nash–Bertrand equilibrium does not exist for this very simple environment, one important property of the Nash–Bertrand equilibrium concept is fulfilled in the present model and using this property can serve as a prediction for the unique pair of prices set by the brand-producing firms in the presence of consumer switching costs. We first introduce a formal definition of undercutting.

Definition 1. Firm i is said to *undercut* firm j , if it sets its price to $p_i < p_j - S$, $i = A, B$ and $i \neq j$. That is, if firm i 'subsidizes' the switching cost of firm j 's customers.

Notice that if, say, firm A undercuts firm B , then by (2) firm A sells brand A to all consumers; that is, $n_A = N_A + N_B$ and $n_B = 0$.

The undercut-proof property is satisfied if there exists a pair of prices so that no

¹It should be pointed out that Shilony (1977) developed mixed-price solutions for a similar model. Also, Eaton and Engers (1990) develop Markov perfect equilibrium solutions for a similar environment.

firm can increase its profit by undercutting the rival firm, and no firm can increase its price without being profitably undercut by the competing firm. Formally²,

Definition 2. A pair of prices $\langle p_A^U, p_B^U \rangle$ is said to satisfy the *Undercut-proof Property (UPP)* if

(a) For given p_B^U and n_B^U , firm A chooses the highest price p_A^U subject to

$$\pi_B^U = p_B^U n_B^U \geq (p_A - S)(N_A + N_B).$$

(b) For given p_A^U and n_A^U , firm B chooses the highest price p_B^U subject to

$$\pi_A^U = p_A^U n_A^U \geq (p_B - S)(N_A + N_B).$$

(c) The distribution of consumers between the firms is determined in (2).

The first part of Definition 2 states that firm A sets the highest price subject to the constraint that firm B will not find it profitable to undercut p_A^U and grab firm A's customers.

The above two inequalities therefore hold as equalities which can be solved for the unique pair of prices

$$p_A^U = \frac{(N_A + N_B)(N_A + 2N_B)S}{(N_A)^2 + N_A N_B + (N_B)^2} \quad \text{and} \quad p_B^U = \frac{(N_A + N_B)(2N_A + N_B)S}{(N_A)^2 + N_A N_B + (N_B)^2}. \quad (4)$$

First, note that by setting $p_i \leq S$, each firm can secure a strictly positive market share without being undercut. Hence, both firms maintain a strictly positive market share. Second, note that $p_A^U, p_B^U > S$. Finally, substituting (4) into (2), we have that $n_A^U = N_A$ and $n_B^U = N_B$.

3. Preparation for fitting actual data

The previous section developed the theoretical framework for calculating prices satisfying the UPP as functions of consumer switching costs. Before turning to demonstrating how switching costs can be calculated from observed prices, I extend the model in two ways: First, the model is extended so it can handle more than two brands (firms). The second extension involves allowing consumers who are oriented towards a specific brand (say because of an earlier purchase) to have different switching costs than others. That is, the extended model allows consumers, whom for historical reasons assigned to different brands, to have different switching costs.

² Appendix A provides some dynamic justification for the use of UPP prices.

3.1. Extending the model to a multifirm industry

Suppose now that there are $I \geq 2$ firms, each indexed by i , $i = 1, \dots, I$. Each firm sets its price denoted by p_i , $i = 1, \dots, I$. The extension from two to I brands goes as follows. Each firm considers whether to undercut one and only one competing firm at a time.³ Clearly, if prices satisfy the UPP then the most profitable firm is the one with the largest clientele, and the least profitable firm is the one with the smallest clientele. Hence, the firm with the smallest clientele has the strongest incentive to undercut and is therefore most likely to undercut all other firms which are more profitable. With no loss of generality, we index the firms according to decreasing market shares from consumers' earlier purchase. Formally, if firms have different market shares, we set

$$N_1 > N_2 > \dots > N_I.$$

If, however, the collected data has $N_i = N_j$ for some firms i and j , then let firm i be the firm that charges the lower price, that is $p_i \leq p_j$.⁴ We assume the following behavior:

- Each firm $i \neq I$ fears to be undercut by firm I , and hence sets its price, p_i , in reference to the price charged by firm I .
- Firm I itself fears that it is targeted by firm 1 and therefore sets its price, p_I , in reference to p_1 so that firm 1 will not find it profitable to undercut its price.

3.2. Solving for the unobserved switching costs

Define S_i to be the switching cost of a brand i consumer, and assume that S_i ($i = 1, \dots, I$) are known to all firms and consumers, but are not known to us (the investigators)! Then, each firm $i \neq I$ takes p_I as given and sets maximal p_i to satisfy

$$\pi_i = p_i N_i \geq (p_i - S_i)(N_i + N_I). \quad (5)$$

That is, each firm i , fearing being undercut by firm I , maximizes its price, p_i so that firm I will not find it profitable to undercut. Since all prices are observed, we can now solve for the unobserved switching costs of the customers of each firm. Solving (5) for the equality case we have

³As pointed out by a referee, an alternative assumption would be that each firm attempts to undercut all firms at the same time. The present assumption can be justified by observing that most 'price wars' are generally triggered between two stores or two brands only.

⁴The reason for this indexing is that under the UPP, the firm with the higher market share charges a lower price (since it is more likely to be undercut). Although the market shares are equal in the present case, measurement errors can still yield different prices which the algorithm must be able to handle.

$$S_i = p_i - \frac{N_i p_I}{N_i + N_I}, \quad i \in \{1, \dots, I-1\}. \quad (6)$$

Eq. (6) is the switching costs of brand i consumers as a function of the prices set by firms i and I , and the firms' market sizes. I now demonstrate how the switching costs of a brand I consumers are determined. The firm with the smallest market share, firm I , assumes that it is the prey target of firm 1. Therefore, firm I chooses a price, p_I , that would make undercutting its price by firm 1 unprofitable. That is,

$$\pi_1 = p_1 N_1 \geq (p_I - S_I)(N_1 + N_I). \quad (7)$$

Since p_I is observed, we can solve for the unobserved remaining switching cost S_I by treating (7) as an equality. Thus,

$$S_I = p_I - \frac{N_I p_1}{N_1 + N_I}. \quad (8)$$

3.3. Interpretation

In reality, consumers may not have the same switching costs. If switching costs result from training or learning by doing, then switching costs will be higher for those consumers who have high value of time (resulting, perhaps, from a higher income). Klemperer (1987a,b) assumes that the demand facing each firm is composed of consumers with different switching costs (see Section 6 of this paper). In his symmetric equilibrium both firms serve different customers, but the distribution of switching costs served by firm 1 is identical to the distribution of switching costs served by firm 2. In this respect, the Klemperer model is more general than the present model. However, in one aspect his models are less general than the present model since in the present model the equilibrium distribution of consumers among brands relates to their switching costs. In other words, Eq. (6) allows for different switching costs. The difference in switching costs is manifested by having consumers with low switching costs buying the less-expensive brand, whereas consumers with high switching costs buy the more-expensive brand. Thus, the equilibrium allocation of consumers among brands is according to their levels of switching costs. In fact, Section 5 below will demonstrate that small banks attract consumers with low switching costs. In contrast, large banks serve consumers who have high switching costs. In this respect, the present model does capture heterogeneous consumers and predicts how they will be distributed among the different firms.

4. Fitting actual data: telecommunication

This section demonstrates the usefulness of the estimation method developed in Section 3 by calculating actual switching costs of cellular-phone users in Israel in 1998.

4.1. A brief description of the Israeli market for cellular phone

In 1998, the cellular phone market consisted of two suppliers: The Pelephone company which started operating in May 1987 using the CDMA and NAMPS technologies; and the Cellcom company which started operating in February 1995 using the TDMA technology. The Ministry of Communication has provided licenses to both companies based on auctions it conducted and the winners were chosen mainly on consumer prices and reliability. Table 1 exhibits the number of subscribers, revenues, and profit of each provider for 1998.

It should be mentioned in January 1999 a third provider called Partner-Orange has started operating using the GSM technology. Given that entry is still in progress, this provider is not included in the present analysis.

Table 1 defines yearly sales per-subscriber as the unit price of cellular phone service. Whereas tariffs per minute and volume discounts are available, I chose to ignore them as they do not reflect the true cost of subscribing to a cellular phone service in Israel. The reason for this is that subscribers are subjected to high fixed fees which include monthly fees as well as phone-insurance fees. Therefore it seems to me that the revenue per-subscriber constitutes a better estimate than per-minute prices.

4.2. Switching costs calculations

Turning to the main purpose of this paper, I now calculate the switching costs of cellular phone users in Israel using the UPP model developed earlier. Substituting the data for the number of subscribers and prices into (6) or (8) yields the switching costs of Pelephone and Cellcom users denominated in NIS.

$$S_p = p_p - \frac{N_c p_c}{N_p + N_c} = 1298, \quad \text{and} \quad S_c = p_c - \frac{N_p p_p}{N_c + N_p} = 945. \quad (9)$$

Eq. (9) demonstrates how the unobserved switching costs can be calculated from observed prices and market sizes. In order to verify that the calculated switching costs (9) indeed make sense we need to ask what types of costs are faced by a subscriber who switches from Pelephone to Cellcom, and vice versa. I can think of

Table 1
The 1998 Israeli market for cellular phone service (NIS=New Israeli Shekel≈USD 0.24)^a

Company's Name:	Pelephone	Cellcom
Profit (mil.NIS):	$\pi_p = 283.5$	$\pi_c = 310$
Sales Revenue (mil.NIS):	$R_p = 2400$	$R_c = 2370$
Subscribers (mil.):	$N_p = 1$	$N_c = 1.15$
Price (Sales/Subs.):	$p_p = 2400$	$p_c = 2061$

^a Source: Haaretz Newspaper, February 14, 1999.

three costs: (i) The expense of purchasing a new phone. This expense is unavoidable given that the two providers operate on different standards. (ii) Partial loss due to multiple subscription fees in case a subscriber switches at a period other than the renewal time. (iii) Value of lost time resulting from a change in the subscriber's phone number. Clearly, the most significant expense is the purchase of a new phone. To get some indication of this expense, the data shows that a common phone sold by these companies averaged NIS 700 to NIS 1400. The switching costs calculated in (9) show that switching costs are approximately equal to the price of an average phone. Thus, these estimated switching costs do not exceed the price of the phone reflecting perhaps the fact that consumers tend to upgrade their phone upon switching to a new provider.

5. Fitting actual data: banking

I now simulate data taken from 1997 Finnish demand-deposit banking industry.

5.1. A brief description of the data

The data consists of the four major banks in Finland and includes:

Number of accounts: which tends to overestimate the active number of accounts as some of these accounts are inactive. I don't have any data showing the relative use of these accounts, so the reader should bear in mind that the number of active accounts is smaller than the one reported, hence the actual fee per active account is higher than the reported fees. The reported figures represent average between the beginning and the end of the year.

Fees: There are various fees charged to account holders.

Direct fees: are upfront fees levied on each account holder for maintaining the account with the bank.

Transaction fees: are the fees paid out for each payment transaction conducted via the bank.

Foregone interest: is an implicit fee which is not actually levied. However, foregone interest can be interpreted as a fee stemming from having a noninterest bearing balance with the bank. These fees are ignored here, but the reader is warned that foregone interest could add to the actual cost of maintaining a bank account by a factor of two.

All fees are computed on an annual basis.

Table 2 shows the data which is used later for the calibration of the switching-cost model. Since fees are annual (and therefore constitute flows rather than a single payment), when a consumer considers switching between banks the consumer should not compare the annual fees but instead compare the discounted

Table 2

The Finnish banking industry 1997 (four largest banks only). All figures are in \$US. Lifetime discounted sum of fees are based on a 4% real interest rate

Data	Bank 1	Bank 2	Bank 3	Bank 4
# Accounts (N_i)	6 017 340	4 727 051	4 051 852	952 093
Average balance	4154	3946	2350	4137
Fees per account	21	19	22	18
Over lifetime (p_i)	525	475	550	450
Switching costs	463	400	464	– 3
SC/avg. bal. (%)	11%	10%	20%	0%

sum of life-time fees since switching is generally a one-time operation (due to switching costs). Therefore, the fees p_i in Table 2 are calculated by discounting the infinite sum of the per-account fees assuming a 4% real interest rate.

5.2. Switching costs calculations

The switching cost, S_i , associated with maintaining an account with bank i is found by substituting the relevant number of accounts, N_i , and p_i into (6) and (8) by considering bank 4 as the smallest bank ($I = 4$). Therefore,

$$S_1 = p_1 - \frac{N_4 p_4}{N_1 + N_4} = 525 - \frac{952\,093}{6\,017\,340 + 952\,093} 450 \approx 463,$$

$$S_2 = p_2 - \frac{N_4 p_4}{N_2 + N_4} = 475 - \frac{952\,093}{4\,727\,051 + 952\,093} 450 \approx 400,$$

$$S_3 = p_3 - \frac{N_4 p_4}{N_3 + N_4} = 550 - \frac{952\,093}{4\,051\,852 + 952\,093} 450 \approx 464,$$

$$S_4 = p_4 - \frac{N_1 p_1}{N_1 + N_4} = 450 - \frac{6\,017\,340}{6\,017\,340 + 952\,093} 525 \approx -3.$$

The calculated switching costs are also displayed in Table 2. The major finding from this exercise is that generally large banks serve customers with high switching costs, whereas the smallest bank serves customers with no switching costs (bank 3 is an exception since it provides a large amount of government services). Also, for this specific data, it turned out that the bank with the lowest fees (bank 4) captures consumers with a low value of time who use this bank because this bank happens to have the lowest fees. That is, for these consumers switching is not costly, so they switch to the bank with the lowest fees. In contrast, banks 1 and 2 which have high fees capture consumers with high value of time for whom switching to banks with lower fees is very costly. The last row in Table 2 provides a measure of the magnitude of switching costs in the market for bank

deposits by looking at the ratio of switching costs to the average balance held in each bank. Thus, ignoring bank 3 again, we can conclude that switching costs account for between 0 to 11% of the average balance a depositor maintains with the bank.

6. Downward-sloping demand: An extension

The model derived in Section 2 relied on unit (perfectly-inelastic) demand structure. In this section I construct a model yielding a downward-sloping demand curve for each brand. The model is similar in many respects to Klemperer (1987b); the main difference is that here I start out with utility functions (and not demand functions) and apply the UPP as the solution concept. Consider a Hotelling (1929) type of environment with $2N$ consumers indexed by x and uniformly distributed on the interval $[0,1]$ according to increasing preference for good B . Assume that out of the population of $2N$ consumers, N consumers have already purchased product A before and therefore will bear a switching cost of S if they buy product B . The remaining N consumers have already purchased product B before and will therefore bear a switching cost of S if they buy product A . Let $\tau > 0$ be the product differentiation parameter (transportation cost parameter). The utility function of a consumer who has purchased product A before and is indexed by x , $x \in [0,1]$ is given by

$$U_\alpha(x) \stackrel{\text{def}}{=} \begin{cases} -\tau x - p_A & \text{continues to purchase A} \\ -\tau(1-x) - p_B - S & \text{switches to product B.} \end{cases} \quad (10)$$

Similarly, the utility function of a consumer who has purchased product B before and is indexed by x , $x \in [0,1]$ is given by

$$U_\beta(x) \stackrel{\text{def}}{=} \begin{cases} -\tau x - p_A - S & \text{switches to product A} \\ -\tau(1-x) - p_B & \text{continues to purchase B.} \end{cases} \quad (11)$$

Define by \hat{x}_A the index number of a consumer who has purchased product A before and is indifferent between repurchasing A and switching to B . The utility function (10) implies that

$$\hat{x}_A = \frac{1}{2} + \frac{S + p_B - p_A}{2\tau}. \quad (12)$$

Similarly, define by \hat{x}_B the index number of a consumer who has purchased product B before and is indifferent between repurchasing B and switching to A . The utility function (11) implies that

$$\hat{x}_B = \frac{1}{2} + \frac{-S + p_B - p_A}{2\tau}. \quad (13)$$

Fig. 1 illustrates how the market is divided between the two firms.

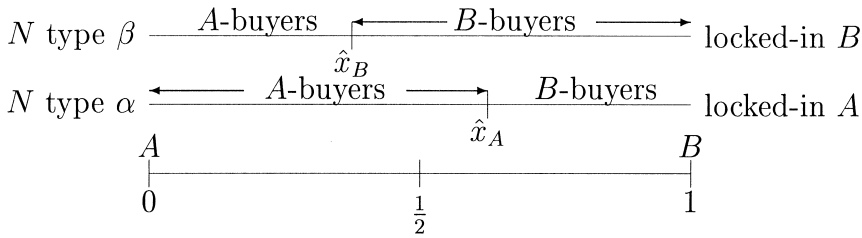


Fig. 1. Market shares with switching costs and downward-sloping demand functions.

Fig. 1 demonstrates that for given firms’ prices, p_A and p_B , each firm sells to two types of consumer groups: those who purchase the same product as before and those who switch. In each group, each firm sells to the consumers with lower ‘transportation cost.’ It is clear that A’s market share among the N consumers who purchased A before is $\hat{x}_A > 1/2$, whereas A’s market share among the N consumers who purchased B before is $\hat{x}_B < 1/2$. Summing up (12) and (13) we obtain the demand function facing firm A

$$Q_A(p_A, p_B) \stackrel{\text{def}}{=} N\hat{x}_A + N\hat{x}_B = N\left(1 + \frac{p_B - p_A}{\tau}\right). \tag{14}$$

Similarly, the demand function facing firm B is given by

$$Q_B(p_A, p_B) \stackrel{\text{def}}{=} N(1 - \hat{x}_A) + N(1 - \hat{x}_B) = N\left(1 + \frac{p_A - p_B}{\tau}\right). \tag{15}$$

We now apply the UPP as the solution concept for calculating equilibrium prices. Fig. 2 illustrates the meaning of undercutting in the context of the present model.

Thus, we define undercutting by firm A as a price reduction of p_A so that $\hat{x}_A = \hat{x}_B = 1$. That is, all consumers buy product A. Note however that in order to calculate the undercutting price of firm A it is sufficient to look for the price where $\hat{x}_B = 1$ since it is clear that if $\hat{x}_B = 1$ it must be that $\hat{x}_A = 1$. That is, if all product B buyers switch to buying A, it must be that all product A buyers remain A-buyers. Therefore, firm A can undercut the price of B by setting

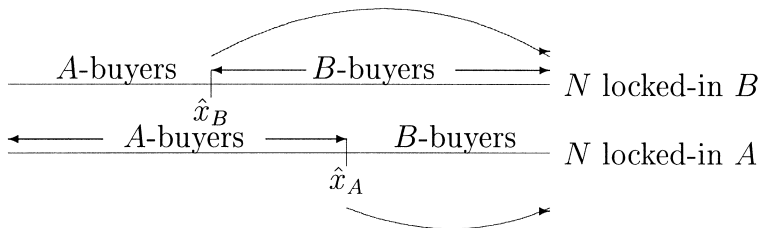


Fig. 2. Firm A undercuts the price of firm B.

$$p'_A \leq p_B - \tau(1 - \hat{x}_B) - S,$$

which means that firm *A* subsidizes both the ‘transportation cost’ of *B*-buyers as well as their switching cost. Altogether, under the UPP and given \hat{x}_A , \hat{x}_B and p_A , firm *B* sets the highest price subject to

$$N(\hat{x}_A + \hat{x}_B)p_A \geq 2N[p_B - \tau(1 - \hat{x}_B) - S]. \tag{16}$$

That is, firm *B* maximizes p_B subject to the constraint that firm *A* will not find it profitable to undercut p_B . Similarly, given \hat{x}_A , \hat{x}_B and p_B , firm *A* sets the highest price subject to

$$N(2 - \hat{x}_A - \hat{x}_B)p_B \geq 2N(p_A - \tau\hat{x}_A - S). \tag{17}$$

The symmetric solution to (16) and (17) is easy to find by observing that if $p_A = p_B$ then $\hat{x}_A = 1 - \hat{x}_B$. Hence,

$$\hat{x}_A = 1 - \hat{x}_B = \frac{1}{2} + \frac{S}{2\tau}, \quad \hat{x}_B = 1 - \hat{x}_A = \frac{1}{2} - \frac{S}{2\tau}, \quad \text{and} \tag{18}$$

$$p_A = p_B = \tau + 3S.$$

Thus, (18) implies that prices increase with an increase in the switching cost parameter, S , and the transportation cost parameter, τ . In addition, an increase in the switching cost parameter, S , increases the number of consumers who do not switch to the competing product; that is, an increase in S increases \hat{x}_A and decreases \hat{x}_B . When the switching cost parameter, S , declines to zero we have $\hat{x}_A = \hat{x}_B = 1/2$ which means that half of the consumers continue to purchase the brand they have purchased before and half of the consumers switch to the competing product.

7. Discussion

The main problem in estimating switching costs involves the determination of whether switching costs constitute a stock cost or a flow cost. In my opinion switching costs are generally stock costs as most users of most systems do not switch to competing services or products very often (or even not at all). Thus, in practice, most consumers do not switch (between operating systems, phone services, airlines, or banks) and therefore do not always bear the switching costs. In fact, the theoretical framework developed in Section 2 emphasizes the point that firms will set prices so that consumers will not find it beneficial to switch brands; thus, switching costs will not be borne or paid by consumers.

Now, if we regard switching costs as stocks, the determination of switching costs as functions of prices (which are flows) creates an interpretation problem as how often consumers make a purchase, and whether the prices used in the calculation of the switching costs should be measured per unit of consumption or

per period of consumption (and how long this period should be?). I do not attempt to answer this question, as this problem prevails in any empirical research involving stocks and flow measurements in a given environment.

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Appendix A. Justifications for the use of the UPP

After reading the paper, the reader may wonder whether the use of the UPP prices (which can be viewed as a specific conjectural variation) has a justification. I would like to claim that there are several justifications for using this property as a predictor of prices. First, any Nash equilibrium must satisfy the UPP. This means that this specific conjectural variation assumption does not contradict the Nash concept, to the contrary, it is an outcome of the Nash concept. Second, it is simple, and can be taught in principles of economics classes. In addition, for the reader who wishes to see how the UPP prices turn out to be an upper bound on subgame-perfect equilibrium (SPE) prices of a dynamic game I now provide this analysis.

In an unpublished paper, Morgan and Shy (1997) generalize the UPP into an equilibrium concept for any number of firms, and calculate the UPP for several commonly-used environments. I will now demonstrate one example showing the relationship between the UPP prices and the dynamic meeting-the-competition game. In this game, consumers purchase from the store that charges the (transportation-cost inclusive) lowest price and in addition, they do not tolerate price increases.

Consider an infinite-horizon discrete-time economy and the two competing brands labeled *A* and *B*. In each period t , ($t = 1, 2, \dots$), N_A *A*-oriented consumers and N_B *B*-oriented consumers reenter the market and purchase at most one unit of one of the brands. Let p_A^t and p_B^t denote the period t brand prices. We now modify the preferences given in (1) by

$$U_\alpha \stackrel{\text{def}}{=} \begin{cases} V_A^t - p_A^t & \text{repurchase A} \\ V_B^t - p_B^t - S & \text{switch to B} \end{cases} \quad \text{and} \quad U_\beta \stackrel{\text{def}}{=} \begin{cases} V_A^t - p_A - S & \text{switch to A} \\ V_B^t - p_B & \text{repurchase B,} \end{cases} \quad (\text{A.1})$$

where

$$V_A^t \stackrel{\text{def}}{=} \min\{V_A^{t-1}, p_A^{t-1}\} \quad \text{and} \quad V_B^t \stackrel{\text{def}}{=} \min\{V_B^{t-1}, p_B^{t-1}\}. \tag{A.2}$$

Eq. (A.2) implies that consumers do not tolerate price increases.

Both firms have zero cost of production. At any date t , firm i 's one-period profit is $\pi_i(p_A^t, p_B^t)$. Let $p^t = (p_A^t, p_B^t) \in \mathfrak{N}_+^2$ be the vector of prices in period t . Let $0 < \delta < 1$ denote the discount factor. At each period t when firm i , $i = A, B$, is entitled to reset its price, each firm maximizes its present-valued profit $\sum_{s=0}^{\infty} \delta^s \pi_i(p_A^{t+s}, p_B^{t+s})$.

In this alternating-moves price-setting game, firm A sets its price in odd periods $t = 1, 3, 5, \dots$, and firm B sets its price in even periods $t = 2, 4, 6, \dots$. Each firm is committed to maintaining its price for two periods. Hence, $p_A^{2t} = p_A^{2t-1}$, and $p_B^{2t+1} = p_B^{2t}$ for all $t = 1, 2, 3, \dots$. It is assumed that firm i 's pricing decision for period t depends only upon prices which prevailed in period $t - 1$. Following Maskin and Tirole (1988), we utilize a Markovian assumption which makes the dynamic best-response function R_i of any firm i dependent only upon the price committed by its rival firm in the previous period and itself, so that $p_i^t = R_i(p^{t-1})$, $i = A, B$; $i \neq j$.

In a *meeting-the-competition* game, each firm states that it would match the (switching-cost inclusive) price of its rival firm, whenever the rival firm undercuts. Formally, the dynamic functions are called meeting-the-competition response functions if for every period t in which firm i is entitled to set its price,

$$p_i^t = R_i(p_A^{t-1}, p_B^{t-1}) \stackrel{\text{def}}{=} \begin{cases} p_i^{t-1} & \text{if } p_j^{t-1} \geq p_i^{t-1} - S \\ p_j^{t-1} + S & \text{if } p_j^{t-1} < p_i^{t-1} - S \end{cases} \quad i, j = A, B, i \neq j. \tag{A.3}$$

Thus, a firm will not alter its price, unless the other firm undercut it in an earlier period. If the competing firm undercuts, the firm matches the reduced price plus the switching cost in a subsequent period. Next, define the dynamically-modified UPP prices by

$$p_A^U(\delta) \stackrel{\text{def}}{=} \frac{[N_A + (1 - \delta)N_B][(1 - \delta)N_A + 2N_B]S}{(1 - \delta)[(N_A)^2 + (1 - \delta)N_A N_B + (N_B)^2]}, \tag{A.4}$$

and

$$p_B^U(\delta) \stackrel{\text{def}}{=} \frac{[(1 - \delta)N_A + N_B][2N_A + (1 - \delta)N_B]S}{(1 - \delta)[(N_A)^2 + (1 - \delta)N_A N_B + (N_B)^2]}. \tag{A.5}$$

Clearly, $p_A^U(\delta) \rightarrow p_A^U$ and $p_B^U(\delta) \rightarrow p_B^U$ as $\delta \rightarrow 0$, where p_A^U and p_B^U are given in (4).

Thus, the dynamically-modified UPP prices converge to the static UPE prices as the discount-rate parameter declines to zero.

The relationship between the UPP and the subgame perfect equilibrium (SPE) for this dynamic game is manifested by the following proposition.

Proposition. Let p_A^0 and p_B^0 be given. The meeting-the-competition response functions (A.3) constitute a SPE if and only if $p_A^0 \leq p_A^U(\delta)$ and $p_B^0 \leq p_B^U(\delta)$.

Proof. Observe that on the equilibrium path, both firms maintain their initial price p_A^0 and p_B^0 , respectively. In a SPE no firm can increase its profit by once undercutting its rival firm. Hence, for (A.3) to constitute a SPE, it must be that for every odd t ,

$$(N_A + N_B)(p_B^{t-1} - S) + \delta N_A \frac{p_B^{t-1} - S}{1 - \delta} \leq N_A \frac{p_A^{t-1}}{1 - \delta}, \text{ or}$$

$$p_A^{t-1} \geq \frac{[N_A + (1 - \delta)N_B](p_B^{t-1} - S)}{N_A}, \quad (\text{A.6})$$

and for every even t ,

$$(N_A + N_B)(p_A^{t-1} - S) + \delta N_B \frac{p_A^{t-1} - S}{1 - \delta} \leq N_B \frac{p_B^{t-1}}{1 - \delta}, \text{ or}$$

$$p_B^{t-1} \geq \frac{[(1 - \delta)N_A + N_B](p_A^{t-1} - S)}{N_B}. \quad (\text{A.7})$$

Suppose that (A.3) constitutes a SPE, but that either $p_A^0 > p_A^U(\delta)$ or $p_B^0 > p_B^U(\delta)$. With no loss of generality, suppose that $p_A^0 > p_A^U(\delta)$. Since (A.4) and (A.5) constitute the unique solution of (A.6) and (A.7), either (A.6) or (A.7) must be violated for any value of p_B^0 . A contradiction. To demonstrate the reverse, suppose that $p_A^0 \leq p_A^U(\delta)$ and $p_B^0 \leq p_B^U(\delta)$. Then, both (A.6) and (A.7) are satisfied, so no firm would have an incentive to deviate from its initial price. \square

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