Transaction, Search and Switching Costs: An Expository Essay

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Abstract

This essay provides an elementary, unified introduction to the impacts of transaction, search and switching costs on resource allocation in competitive markets. The emphasis is on incorporating these phenomena into models of price-taking behavior, rather than the more usual treatments with imperfect competition.

Keywords: transaction costs, search costs, switching costs, competitive markets, price-taking

Introduction

The three terms in the title of this essay cover a wide array of phenomena, with as many ways of modeling them. A broad unifying theme is that these costs introduce frictions in the working of markets. The goal of the analysis in this essay is to show how these costs or frictions affect economic behavior. We use the standard competitive model as our benchmark, and focus on models that deviate from the standard model in specific ways associated with the introduction of the particular cost. This integration of market frictions into the standard competitive model is not provided in standard textbooks of microeconomics (e.g., Kreps, 1990; Mas-Colell et al., 1995; Varian, 1992), so it is hoped that this essay fills that gap to some extent.

The treatment of each of these topics is not meant to be comprehensive or even representative of all the modeling techniques that can be used, but instead emphasizes the connections between models of market frictions and the standard competitive model with price-taking behavior. For example, models of switching costs (Klemperer, 1987, 1995) typically focus on imperfect competition and strategic behavior. To give another example, in the case of search costs, the great majority of economic models build on the assumption that searches are conducted sequentially. In the treatment presented here, we focus instead on an approach that allows for connections to the standard theory of consumer behavior to be seen more easily. This approach assumes that search consists of collecting a given number of pieces of information (price quotes, in the model presented) together, rather than one by one, with the number being decided in advance.

Transaction Costs

Transaction costs can be used to refer to all kinds of factors that introduce frictions into the working of markets. Often, the term is used to include inefficiencies associated with asymmetries of information (Williamson, 1975). However, those are better treated explicitly and separately (Singh, 2010a, 2010b). Here we use transaction costs to refer specifically to additional resource costs associated with a market transaction, beyond the price paid by the buyer. The price is a transfer payment from buyer to seller, whereas the transaction cost is a real resource cost. We might think of it as a cost of production associated with "producing" a market transaction.

From an individual choice perspective, if a consumer is only a buyer of goods and services, then there is no essential change in her decision problem. We first illustrate this point through three variants of transaction costs: fixed costs, per unit costs, and proportional costs. In the case of fixed costs, the individual's choice problem is of the form

$$\text{Max} \quad U(x_1,...,x_K) \quad \text{subject to} \quad p_1x_1 + p_2x_2 + ... + p_Kx_K = I - \sum_1^K c_k \qquad (1)$$

where c_k is the fixed cost of buying good *k*. This assumes that positive quantities of each good are produced. Changes in fixed transaction costs of this type are equivalent to changes in money income.

If transaction costs are per unit costs, say constant for simplicity, then the decision problem is:

$$\text{Max} \quad U(x_1,...,x_K) \quad \text{subject to} \quad (p_1+t_1)x_1 + (p_2+t_2)x_2 + ... + (p_K+t_K)x_K = I \qquad (2)$$

Now the transaction costs have the same impact as per unit taxes. Changes in transaction costs have impacts equivalent to changes in prices. For example, the elasticity of consumption of good *k* with respect to its transaction cost is exactly the same as its own-price elasticity.

Finally, proportional transaction costs are formally identical to ad valorem taxes, giving a consumer choice problem of the following form:

$$\begin{aligned} &\text{Max} \quad U(x_1,...,x_K) \\ &\text{subject to} \quad p_1(1+\tau_1)x_1 + p_2(1+\tau_2)x_2 + ... + p_K(1+\tau_K)x_K = I \end{aligned} \qquad (3)$$

In this case, if $p_k^\tau \equiv p_k(1+\tau_k)$, then $\frac{\partial x_k^*}{\partial \tau_k} = \frac{\partial x_k^*}{\partial p_k^\tau}\frac{\partial p_k^\tau}{\partial \tau_k} = \frac{\partial x_k^*}{\partial p_k^\tau} p_k = \frac{\partial x_k^*}{\partial p_k^\tau}\frac{p_k^\tau}{(1+\tau_k)}$. Hence, the elasticity of demand with respect to the transaction cost is given by

$$\frac{\tau_k}{x_k^*}\frac{\partial x_k^*}{\partial \tau_k} = \frac{p_k^\tau}{x_k^*}\frac{\partial x_k^*}{\partial p_k^\tau}\frac{\tau_k}{(1+\tau_k)} \tag{4}$$

i.e., the price elasticity adjusted by the ratio of transaction cost to total cost of the good. Again, in this case, from the single individual's perspective, the analysis of transaction costs is equivalent to that for a model of taxation.

To see explicitly how transaction costs drive a wedge between the expenditures of buyers and the receipts of sellers, consider a case where the consumer has endowments of each good, rather than an endowment of money income. For simplicity, suppose there are only two goods. Assume that transaction costs are of the per unit form (the second of the three formulations). Then $p_k^B \equiv (p_k + t_k)$ is the price paid if the good is bought, while $p_k^S \equiv p_k$ is the price received if the good is sold.

The consumer's endowment vector is (ω_1, ω_2), and her trade vector is $(z_1, z_2) \equiv (x_1 - \omega_1, x_2 - \omega_2)$. Hence, the price faced by the individual depends on the sign of the relevant z_k, p_k^B if $z_k > 0$ and p_k^S if $z_k < 0$. There are several ways to express the consumer's choice problem in this case. One approach is to impose two inequality constraints, since one or the other will be binding depending on which good the consumer buys and which she sells at her utility maximizing choice. The maximization problem is therefore:

$$\begin{aligned} &\text{Max} \quad U(\omega_1 + z_1, \omega_2 + z_2) \\ &\text{subject to} \quad p_1^B z_1 + p_2^S z_2 \le 0 \quad \text{and} \quad p_1^S z_1 + p_2^B z_2 \le 0 \end{aligned}$$

Since $p_k^B > p_k^S$, if $z_1 > 0$ and the first constraint is binding, the second constraint must be slack. However, if $z_1 < 0$ and the first constraint is binding, the second constraint would be violated. This shows that the consumer indeed pays the higher price (including the transaction cost) if she is a buyer of the good.

The first order conditions are:

$$\begin{aligned}
&\frac{\partial U}{\partial x_1} - \lambda p_1^B - \mu p_1^S = 0 \\
&\frac{\partial U}{\partial x_2} - \lambda p_2^S - \mu p_2^B = 0 \\
&\lambda(p_1^B z_1 + p_2^S z_2) = 0 \quad \text{and} \quad \mu(p_1^S z_1 + p_2^B z_2) = 0
\end{aligned} \tag{5}$$

If preferences and prices are such that she is a net buyer of good 1, then

$$\frac{\partial U / \partial x_1}{\partial U / \partial x_2} = \frac{p_1^B}{p_2^S} \tag{6}$$

If instead she is a net seller of good 1 in her choice equilibrium, then

$$\frac{\partial U / \partial x_1}{\partial U / \partial x_2} = \frac{p_1^S}{p_2^B} \tag{7}$$

Now consider the situation with many consumers, all facing the same market prices, reflecting the same transaction costs. Depending on their preferences and endowments, some will be net sellers of good 1, while others will be net buyers. The marginal rate of substitution of good 1 for good 2 (MRS_{12}) for the net buyers is strictly greater than MRS_{12} for the net sellers. However, they cannot improve on this situation because of the transaction cost involved in trading in the market.

Suppose, however, that different consumers face different transaction costs. In particular, suppose that one consumer is able to buy and sell without transaction costs. Then, if all other consumers trade only with this consumer, she can enable all marginal rates of substitution to be equated to her price ratio, which does not involve transaction costs. Effectively, she acts as a central exchange for all other consumers. Instead of a privileged consumer, there might be a firm that has an efficient transaction technology. Then all consumers can trade through the firm, which again acts as an exchange.

The firm might have some costs of running this exchange. Suppose that the total volume of transactions on the buyers' side of the market for good k is Z_k. In the absence of the exchange, the cost of these transactions would be $t_k Z_k$. This is a resource cost measured in terms of units of good k. The firm may have a fixed cost F, as well as unit costs per transaction of c_k. As long as $F + c_k Z_k < t_k Z_k$, then the firm can do better acting as an intermediary. If competition pushes profits to zero, then the firm charges a transaction fee that is still lower than the previous transaction cost. If the fixed cost is zero, the transaction fee with competition to provide exchange services is c_k. Alternatively, suppose that the exchange's unit transaction cost is zero. Then the competitive fee should be F / Z_k.

Note that the above discussion simplifies, by neglecting the effect on transaction volume of the lowering of transaction costs. The transaction volume will increase as transaction costs are reduced by the introduction of a lower cost exchange. There is a related phenomenon which can be very important. Given the spread between buying and selling prices created by transaction costs, it is possible that there could be no trade at all. A no-trade equilibrium for a consumer occurs if

$$\frac{p_1^S}{p_2^B} < \frac{\partial U / \partial x_1}{\partial U / \partial x_2} < \frac{p_1^B}{p_2^S} \tag{8}$$

at the initial endowment point. Without transaction costs, a consumer with MRS_{12} greater than the price ratio (the left hand inequality would want to buy good 1 and sell good 2, but then the right hand inequality comes into play, and that says that it is not worthwhile. This is an argument for a single consumer, but it could apply to all consumers. In that case, if transaction costs are high enough, an active market may not exist at all. Lowering transaction costs, for example by creating an exchange that reduces trading costs, may create an active market where there was none. Trading volume may go from zero to a significant amount.

The above discussion focuses on trading volume, implicitly in a situation without production. If trade does not occur, then individuals consume their endowments. However, if there are transaction costs that keep produced goods from being traded, then they will not be produced. Hence the welfare losses from transaction costs that prevent markets from being active may be quite substantial, because they include losses in product variety – some goods are not available at all. Another factor can further magnify these welfare losses. This happens when growth depends on the production of some goods. Stunting of growth is a further welfare loss from high transaction costs.

Search Costs

The standard model of consumer behavior assumes that consumers know the prices they face. If a consumer in this situation faces different sellers with different prices for the same good, she will always choose the lowest price seller. Hence, when prices are costlessly known to consumers, there cannot be any price dispersion – higher priced sellers would have no customers. In practice, search can be costly, and this allows price dispersion to persist, even in equilibrium. The topic of price dispersion and search costs has received renewed attention because of the introduction of online shopping. It is now possible to collect detailed data on price dispersion online versus across traditional sellers, to see how lower search costs affect equilibrium price dispersion.

Many models of search assume that price search is sequential – this focuses attention on a dynamic process of search, and the analysis answers the question, what is the rule for deciding when to stop the search and buy? Alternatively, a consumer may acquire a sample of different sellers' prices, and make a decision form that set, or keep searching. Both kinds of search technology are possible. The latter allows one to examine how insights of the standard consumer choice model carry over to the case of costly price search, and we explore this example here. We restrict the analysis to price search, but consumers may also search for different levels of quality, or price-quality combinations.

The Model[1]

The only deviation from the standard model will be that the price of a single commodity is not known with certainty. Say this is good 1. All the K goods are bought simultaneously when the consumer's search is completed. The price of good 1 differs across sellers, but each seller of the good quotes a single price. The consumer does not know sellers' pricing strategies or choices a priori, so views any price quote as a draw from a distribution with a known probability density function.

In this situation, the consumer decides how many price quotes to obtain, say n, each quote being from a different seller. These requests are made before any responses are received, so the responses are reviewed simultaneously. Each quote incurs a fixed cost, say c, for the consumer. It is convenient to express the price of good 1 as a base or list price, p_1, multiplied by a discount factor, λ. From the consumer's perspective, each price quote is a draw from the distribution of this random variable. We assume it is a continuous variable, and has a probability density function $f(\lambda)$. The consumer will choose the lowest of the n price quotes.

To proceed with the analysis, we need to recognize that the distribution of the lowest discount factor from the given sample is different from the original distribution of λ. Furthermore, it depends on the number of quotes obtained. We will denote it by $g(\lambda_m \mid n)$, where λ_m is the random variable given by

[1] The model presented here is that of Manning and Morgan (1982).

$\lambda_m = \min(\lambda_1,...,\lambda_n)$.

In fact, there is a precise expression for the new density function, which is

$g(\lambda_m \mid n) = n\,(1 - F(\lambda_m))^{n-1} f(\lambda_m)$,

though this expression does not matter for the subsequent analysis.

The Choice Problem

The consumer's choice problem can be analyzed in two stages. At the first stage, she chooses n and gets that many quotes. At the second stage, she makes her allocation decisions based on the lowest price quote for good 1. As is usual in such cases, since the first stage decision is based on looking forward to what the best choice in the second stage will be, we must solve the second stage first (backward induction).

In the second stage problem, there is no uncertainty, and the consumer's choice problem is as follows, where I is the consumer's income:

$$\text{Max} \quad U(x_1,...,x_K) \quad \text{subject to} \quad \lambda_m p_1 x_1 + p_2 x_2 + ... + p_K x_K = I - cn \qquad (9)$$

We will assume that the utility function and parameters are such that this problem has an interior solution for all the quantities in the consumption bundle, and the solution is unique.

In its essence, therefore, the second stage problem is no different from the standard consumer choice problem. The result of the utility maximization is therefore K demand functions, and an indirect utility function denoted by $V(\lambda_m p_1, p_2,..., p_K, I - cn)$. This indirect utility function has all the standard properties.

Turning to the first stage choice, the indirect utility function includes a random variable in its first argument. Hence, assuming that we can use the expected utility framework, the consumer's first stage choice is to choose n to solve the following problem:

$$\text{Max} \quad \int_a^b V(\lambda_m p_1, p_2, ..., p_K, I - cn) g(\lambda_m \mid n)\, d\lambda_m \qquad (10)$$

Here [a, b] is the interval over which the density of the discount factor is defined.

While n is strictly speaking an integer, it is convenient to treat it as a continuous variable. This is reasonable as long as the objective function is concave in the optimizing variable, which ensures that the true integer solution will be approximated by the solution to the first order condition of a calculus optimization problem. The first order condition has the following simple form which simply says that the marginal benefit of extra search should be equal to its marginal cost, to maximize the expected utility of searching.

$$\int_a^b V(\lambda_m p_1, p_2, ..., p_K, I - cn) \frac{\partial g(\lambda_m \mid n)}{\partial n} d\lambda_m = c \int_a^b \frac{\partial V(\lambda_m p_1, p_2, ..., p_K, I - cn)}{\partial I} g(\lambda_m \mid n)\, d\lambda_m \quad (11)$$

The marginal benefit of extra search is the left hand side term, and the benefit comes about from improving the chance of getting a lower price by searching more. The right hand side is the marginal cost of extra search, and reflects the resources used up in the search, since they reduce disposable income for purchases of goods.

Properties of the Solution

We will now show how the analytical tools used in textbook treatments of consumer choice under certainty and under uncertainty (Singh, 2010a) can be applied to the economics of the consumer search decision.

First, we examine conditions under which the maximand in (2) is strictly concave in n, so that there is a unique maximum for the level of search (the number of quotes the consumer decides to get). Twice differentiating the maximand in (2) gives the following expression:

$$
\begin{aligned}
&\int_a^b V(\lambda_m p_1, p_2,\ldots,p_K, I-cn)\frac{\partial^2 g(\lambda_m \mid n)}{\partial n^2}d\lambda_m \\
&-2c\int_a^b \frac{\partial V(\lambda_m p_1, p_2,\ldots,p_K, I-cn)}{\partial I}\frac{\partial g(\lambda_m \mid n)}{\partial n}d\lambda_m \\
&+c^2\int_a^b \frac{\partial V^2(\lambda_m p_1, p_2,\ldots,p_K, I-cn)}{\partial I^2}g(\lambda_m \mid n)\,d\lambda_m
\end{aligned}
\qquad (12)
$$

The expression contains three integrals. The third integral is non-positive if the first term in the integrand is non-positive. This is true as long as the marginal utility of income is non-increasing. That, in turn, is equivalent to risk neutrality or risk aversion with respect to income uncertainty. Signing the first two integrals requires some further assumptions, in addition to exploiting the specific functional form of the conditional density *g*. Without going into details, we will simply state that the requisite additional condition is that

$$
\frac{\partial V^2(\lambda_m p_1, p_2,\ldots,p_K, I-cn)}{\partial I \partial(\lambda_m p_1)} \le 0 \qquad (13)
$$

This ensures that the second term is non-positive. The first term is negative simply from the fact that the indirect utility decreases each price. In fact, the first term is the marginal benefit of extra search, and it is intuitive that adding price quotes will have smaller effects if many quotes have already been obtained.

The signs of the second and third terms in (12) capture the idea that the marginal cost of search should increase with the size of the search. There are two effects causing this. First, the larger is the search, the greater is the expenditure on search, and the lower is income left for purchasing consumer goods. But this implies that the marginal utility of income is higher, and so the cost of further spending on search is greater, the larger the search, because of the diminishing marginal utility of income. The third term in (12) captures this effect. Secondly, since a larger search increases the chance of finding low prices, (5) implies also that the marginal utility of income is greater the larger is the search. This also implies that the cost of further spending on search goes up with search. The second term in (12) captures this effect.

Condition (5) can be analyzed further. Recall that Roy's identity states that

$$x_i^* = -\frac{\partial V/\partial p_i}{\partial V/\partial I} \tag{14}$$

Rearranging (6) and differentiating, we get that

$$\frac{\partial^2 V}{\partial I \partial p_i} = \frac{x_i^* \, \partial V/\partial I}{I}(R - \eta_i) \tag{15}$$

where

$$R = -\frac{I\,\partial^2 V/\partial I^2}{\partial V/\partial I} \tag{16}$$

is the coefficient of relative risk aversion, and

$$\eta_i = \frac{I}{x_i^*}\frac{\partial x_i^*}{\partial I} \tag{17}$$

is the income elasticity of demand for good *i*.

Hence, condition (5) is a statement about the relative magnitudes of the coefficient of relative risk aversion and the income elasticity of demand.

The Demand for Search

In this framework, search is also an economic good, and the solution to (2), if unique, defines a function $n^*(p_1, p_2, ..., p_K, c, I)$. This can be considered the demand function for search, with c as the unit price of search. As one should expect, this demand function is homogeneous of degree zero in its arguments, $p_1, p_2, ..., p_K, c, I$. Note that neither the two stage nature of the consumer's choice, nor the uncertainty involved in the first stage decision, have a bearing on this property of the demand function.

Next we describe some further properties of the demand for search. In doing so, we assume that the previous conditions used above hold true. First, it is true that the demand function is downward sloping:

$$\frac{\partial n^*}{\partial c} < 0 \tag{18}$$

Furthermore, this price effect can be decomposed into substitution and income effects, in a version of the Slutsky equation.

$$\frac{\partial n^*}{\partial c} = \frac{\partial n^*}{\partial c}\Big|_{EV \text{ constant}} - n^* \frac{\partial n^*}{\partial I} \tag{19}$$

Given the assumptions on the indirect utility function derived from the second stage, it is also true that search is a normal good:

$$\frac{\partial n^*}{\partial I} \geq 0 \tag{20}$$

This result is not as obvious as it seems. It has been plausibly argued that a consumer who is wealthier would search less, since she would be less sensitive to higher prices. However, in this particular specification of search, higher income leads to more search at the consumer's optimum.

The demand for search is tied closely to the demand for good 1. In particular, if the share of expenditure allocated to good 1 rises when its price rises (in other words, good 1 has a price-inelastic demand), it is true that $\partial n^* / \partial p_1 > 0$. Since good 1 is more expensive in expectation (whatever the discount factor turns out to be), it pays to search more if consuming the good is going to take a greater share of expenditure. Alternative conditions, which ensure that good *j* and good 1 are substitutes, will ensure that a rise in the price of the substitute good also has a positive effect on search, $\partial n^{*}/\partial p_{j} > 0$. The economic intuition is straightforward: the consumer searches more to be able to substitute good 1 more effectively for the higher priced alternative.

Extended Slutsky Equation

While the second stage choice problem is made under certainty, once the consumer has received *n* price quotes for good 1, and chosen the lowest one, the demands are contingent on the realization of λ_m. Hence, looking at the situation in the first stage, before the search is undertaken, the consumer's demand functions for the *K* goods are also random. Using the distribution of λ_m, conditional on n^*, we can define expected demands, $\overline{x}_i^*$. The price effect for any expected demand can then be decomposed into an expected substitution effect, and expected income effect, and a search effect. The extended Slutsky equation has the following form:

$$\begin{aligned}\frac{\partial \overline{x}_i^*}{\partial p_j} &= \int_a^b \frac{\partial x_i^*}{\partial p_j}\Big|_V \, g(\lambda_m \mid n^*)\, d\lambda_m - \int_a^b (x_i^* + c\frac{\partial n^*}{\partial p_j})\frac{\partial x_i^*}{\partial I}\, g(\lambda_m \mid n^*)\, d\lambda_m \\ &\quad + \frac{\partial n^*}{\partial p_j}\int_a^b x_i^* \frac{\partial g(\lambda_m \mid n^*)}{\partial n}\, d\lambda_m\end{aligned} \tag{21}$$

Switching Costs

Much of the economic analysis of switching costs focuses on their impacts on the nature and level of competition. Thus, the emphasis is on the strategic behavior of different suppliers of what is potentially a homogeneous good. In a competitive model, these considerations do not come into play, and we will postpone them until we have dealt with imperfect competition in the context of strategic behavior. Nevertheless, it is useful to begin with a broad discussion of switching costs.

Klemperer (1987), who is responsible for much of the seminal work on the economics of switching costs, identifies three types of costs of switching "between brands of products that are ex ante undifferentiated" – transaction costs, learning costs, and artificial or contractual costs. Thus, as noted earlier in the essay, transaction costs can be a source of switching costs. They may be financial costs, such as paying a set-up fee, or time costs, such as filling out forms. In the latter case, one can impute a monetary value to the time expended. They could also be one-time psychological costs, which can be reflected directly in the utility function. Learning costs are associated with using a product, and incurred after the switch, rather than in the process of switching. Our standard model of consumer behavior does not really allow for learning, assuming that the transformation of consumption into utility is automatic. Contractual restrictions or reward programs also can create switching costs, but these are not real resource costs, as is the case with the first two categories of switching cost. As noted, we focus on modeling consumer behavior here, leaving firms' strategic behavior for a later essay.

A Model with Adjustment Costs

The essence of a switching cost situation is that there must be the possibility of repeat consumption. Hence, we will consider a two-period consumption problem. To keep things simple, we assume that there is no scope for storage, or for saving or borrowing. Nor is there any uncertainty. Hence, in the absence of switching costs, a consumer's choices will be the same in each period. Denote the periods by subscript t, where t=1, 2. Then the consumer's standard problem in each period is given by

$$\begin{aligned} &\text{Max} \quad U(x_{t1},...,x_{tK}) \\ &\text{subject to} \quad p_1 x_{t1} + ... + p_K x_{tK} = I \end{aligned} \tag{22}$$

How can one introduce switching costs into this situation? One approach is to recognize that a switching cost is itself a special case of an adjustment cost. Suppose that the consumption level of good 1 is subject to an adjustment cost in the second period. Let this be a cost of μ per unit of adjustment. Then the cost of consumption of level x_{21} in period 2 is given by $p_1 x_{21} + \mu | x_{21} - x_{11} |$. The first term is just the expenditure on good 1 in period 2, while the second term is the cost incurred in adjusting the level of consumption from that in the first period. However, note that if preferences, prices and income do not change across periods, then there is no reason for the consumer to change her consumption choices, and the adjustment cost is irrelevant.

To illustrate the impact of a change, suppose that the price of good 1 in period 2 goes down, to p_1', such that $p_1' + \mu < p_1$, and assume that the consumer's preferences are such that demand for good 1 is downward sloping. Then the consumer's period 2 choice problem is given by

$$\begin{aligned} &\text{Max} \quad U(x_{21},...,x_{2K}) \\ &\text{subject to} \quad (p_1' + \mu)x_{21} + ... + p_K x_{2K} = I + \mu x_{11} \end{aligned} \tag{23}$$

In constructing this, we have assumed that $x_{21} - x_{11} > 0$, which comes from the assumption of downward sloping demand. The presence of x_{11} on the right hand side of the budget constraint indicates that a higher consumption of good 1 in period 1 has a kind of income effect on the choice in period 2. The period 2 indirect utility function has the form $V(p_1' + \mu_1, p_2,..., p_K, I + \mu x_{11})$.

In period 1, the consumer knows that she will face a lower price for good 1 in period 2, and that there will be an adjustment cost associated with increasing the level of consumption of good 1 from the level in period 1. We can think of the increase as a "switch" in the level of consumption, so in that sense μ is a unit switching cost. The main point is that the knowledge of what will happen in period 2 will affect the consumer's period 1 choice. Her period 1 choice problem is now

$$\begin{aligned} &\text{Max} \quad U(x_{11},...,x_{1K}) + V(p_1' + \mu_1, p_2,..., p_K, I + \mu x_{11}) \\ &\text{subject to} \quad p_1 x_{11} + ... + p_K x_{1K} = I \end{aligned} \tag{24}$$

Clearly, she will choose a higher level of good 1 in period 1 in this case, than in the absence of the adjustment or switching cost. Anticipating the effects of future switching costs has implications for the optimality of present choices.

We began with the above example to connect the idea of switching costs to the standard consumer choice model. Next we analyze a more traditional switching cost situation, where there is actually the possibility of a switch between goods, and not just an adjustment of consumption levels.

A Simple Switching Cost Model

The following model assumes that the consumer is uncertain about the quality (or personal suitability) of a good before trying it. Once she has tried it, she knows its value, and can decide whether to switch or not, depending on what she experiences and learns. Switching costs can affect the decision whether to switch (to another brand), and hence the decision whether to try a good with uncertain quality. We will first describe the model without switching costs, and then show how switching costs matter.

To keep matters simple, we assume that only one unit of the good is consumed in any period, and that there are only two periods. There are two goods, one of which comes in two brands, 1 and 2. The other good is good 0, say, and to further simplify, we assume that the utility function is linear and separable in the consumption of good 0. Hence, the utility function is given by

$$U(x_i) + x_0, \quad i = 1 \text{ or } 2 \tag{25}$$

Further simplifying assumptions are that the price of good 0 is 1 (it is the numeraire good), and the price of each brand is the same, p. Income is I.

The consumer knows exactly what utility she will get from consuming brand 1. Let $U(x_1 = 1) \equiv u_1$ and $U(x_1 = 0) = 0$. Then she would purchase brand 1, versus not consuming it, if $u_1 + I - p > I$, or $u_1 > p$. Suppose this holds.

Now suppose that the consumer does not know the utility from consuming brand 2. There are two possibilities. Either she will like the brand, and it has utility u_{2H}, or she does not, and her utility is u_{2L}, where $u_{2H} > u_{2L}$. Let the probability of the better outcome be π. Then she will prefer to purchase brand 2 over not consuming it if $\pi u_{2H} + (1-\pi)u_{2L} > p$. We assume this holds as well: thus she prefers to consume one of the two brands over not consuming either.

If the consumer only faces a one-time choice, then the condition is: choose brand 1(brand 2) if

$$u_1 > (<)\ \pi u_{2H} + (1-\pi)u_{2L} \tag{26}$$

If the two expressions in (18) are equal, then she is indifferent between the two brands.

Now consider the following situation. There are two periods, and the consumer chooses once in each period, with the same budget constraint. There is no storage or saving or borrowing possible, and the second period is not discounted. However, after the consumer chooses brand 2 in period 1, she will know the utility she gets in period 2 from that brand, since she has experienced it once. Suppose that the following inequalities hold:

$$u_{2H} > u_1 > \pi u_{2H} + (1-\pi)u_{2L} \tag{27}$$

The first inequality says that, if brand 2 turns out to be to the consumer's liking, it is better than brand 1. The second inequality says that, before brand 2's utility is known, it is worse in expected utility terms than the known brand 1.

What choices should the consumer make in each period? If she chooses brand 1 in period 1, then she learns nothing about brand 2, and should choose it in period 2, from the second inequality in (19). Her utility from this consumption (not worrying about the utility from consuming good 0, which is the same across all choices), is $2u_1$.

However, if the consumer chooses brand 2 in period 1, she either learns it is to her liking, in which case she can stick with it in period 2, or it is not, in which case she can switch to brand 1. Her expected utility in period 1 is $\pi u_{2H} + (1-\pi)u_{2L}$, while in period 2 (assessing it before consumption has taken place even in period 1), it is $\pi u_{2H} + (1-\pi)u_1$.

Our assumption in (19) ensured that the consumer's best one-time choice is brand 1. However, the expected utility from choosing brand 2 in period 1, with the possibility of switching, is $2\pi u_{2H} + (1-\pi)(u_{2L} + u_1)$. The consumer will choose brand 2 in this situation if

$$2\pi u_{2H} + (1-\pi)(u_{2L} + u_1) > 2u_1 \tag{28}$$

Rearranging this inequality, we get

$$2\pi(u_{2H} - u_1) > (1-\pi)(u_1 - u_{2L}) \tag{29}$$

We can see that (21) is consistent with the second inequality in (19) by rearranging that as

$$\pi(u_{2H} - u_1) < (1-\pi)(u_1 - u_{2L}) \tag{30}$$

Clearly, it is possible that both inequalities hold simultaneously.

All of this discussion so far has been without switching costs. Now suppose there is a switching cost of μ if the consumer switches brands between periods. A cost associated with switching from brand 1 to brand 2 is irrelevant, since that switch will never occur.

However, choosing brand 2 in period one implies a probability $(1-\pi)$ of incurring the switching cost μ. Hence condition (21) for the optimality of trying brand 2 becomes more stringent:

$$2\pi(u_{2H}-u_1) > (1-\pi)(u_1+\mu-u_{2L}) \tag{31}$$

The right hand side in (23) is larger than in (21). The switching cost makes trying brand 2 worthwhile for a smaller range of the other parameters.

Artificial Switching Costs and Competition

The discussion above has assumed that the switching cost is an exogenous cost, for example, some kind of transaction cost associated with making the switch, or a cost of learning to use a different product. It is possible that the switching cost is something that can be influenced by the sellers of the different brands. In the example, sellers of brand 2 actually want the switching cost to be as low as possible (assuming it is nonnegative), to induce the consumer to try out the unknown brand. An exogenous switching cost might also be counteracted by some payment to the consumer, and sellers may want to make this payment.

Suppose first that there is no exogenous switching cost, and (21) holds. Let c be the unit production cost for each brand. Then brand 1 sellers make expected profits in the two periods of $(1-\pi)(p-c)$. Brand 2 sellers' expected profits are $(1+\pi)(p-c)$. If competition drives price down to marginal cost, then both types of sellers make zero profits in equilibrium.

Now suppose that the seller of brand 1 can create an artificial switching cost for consumers who want to switch from brand 2 to brand 1. The seller bears a cost equal to this switching cost. Denote this by μ again, but suppose that it is large enough to deter switching, i.e., inequality (23) is reversed. If the seller of brand 2 can counteract this by making a payment, say ν, toward the consumer's switching costs, this seller will want this payment to be just large enough to allow switching. This would imply that

$$2\pi(u_{2H} - u_1) = (1-\pi)(u_1 + \mu - \nu - u_{2L}) \tag{32}$$

Given (21), for (24) to hold, it must be true that $\mu - \nu > 0$.

If brand 2 is chosen in period 1 then brand 1 sellers' expected profits are $(1-\pi)(p-c-\mu)$, while brand 2 sellers' expected profits are $(1+\pi)(p-c)-(1-\pi)\nu$.

With competition, both these profit expressions should be zero. These will give two independent expressions for p in terms of μ and v respectively, allowing us to derive a relationship between of μ and v. The two zero profit conditions imply that

$$\mu^* = \frac{(1-\pi)}{(1+\pi)}\nu^* \text{ or } \mu^* - \nu^* = \frac{2\pi}{(1+\pi)}\nu^* \tag{33}$$

Substituting this into (24) gives the expression that determines the equilibrium level of brand 2 sellers' choice variable v, and the other variables are then also determined.

Several points are worth noting with respect to the analysis above. It has been assumed that the cost of introducing the switching cost for brand 1 sellers is equal to the switching cost itself. Hence, the expected cost to society of this strategy is $2(1-\pi)\mu$. Suppose that the sellers' cost of introducing the switching cost is $k\mu$. Then k enters the denominator of the expressions in (25). Clearly, if k is small enough, no equilibrium of the form described above will exist. In contrast to μ, we have assumed that the payment by brand 1 sellers is a transfer to consumers, so it is not a social cost.

Another point to note is that the analysis assumes that both types of sellers charge the same price. Given that the consumer is able to distinguish between the two brands, it is plausible to argue that the market prices should be allowed to differ. In that case, all the inequalities such as (21) would have to be modified by including additional terms reflecting the price differential between brands. Furthermore, we cannot equate prices across the zero profit conditions to derive a relationship between the switching cost and counter-payment, as we did in (25). This leaves the equilibrium indeterminate. One could assume, for example, that the switching cost is technologically determined, and this would then allow the other three variables (two prices and the counter-payment) to be determined in equilibrium.

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