# Loss Aversion, Price and Quality*

Hugh Sibly
School of Economics
University of Tasmania
GPO Box 252-85
Hobart, Tas., 7001
Australia

Ph (03) 62262825
Fax: (03) 62267587
(IDD Code + 61 + 3 + )
Email: hsibly@postoffice.utas.edu.au

October 2002

**Abstract**

The Spence model (1975) is extended so that customers' utility depends on their disposition to the firm in addition to quantity and quality of the good consumed. Disposition is determined by customers' perception of firm's pricing and quality decisions, which perception is 'reference dependent'. The profit maximising, efficient, and Ramsey price and quality combinations are derived. Adjustment to a change in economic conditions may call for price rigidity, quality rigidity or both depending on the level of the reference price and quality.

---

* I would like to thank Peter Earl and Ian McDonald for their thoughtful comments on this work. All errors remain my responsibility.

# Loss Aversion, Price and Quality

Virtually all goods have attributes other than their price. Aspects of quality, interpreted broadly to include durability, service level, reliability of supply, quantity per unit package, and advertising to establish a brand image, can be varied for most goods. As customers judge these goods on the basis of both price and quality, the choice of quality is often as important to a firm as is its choice of price. Therefore, following a change in economic conditions (such as a demand or cost shock), firms will wish to re-evaluate their provision of quality as well as their price. However, although Carlton (1989) has emphasised it is not price adjustment alone which clears markets following a change in economic conditions, the overwhelming volume of the literature focuses on price setting assumes quality is set exogenously.

This paper is concerned with a monopolist's adjustment of price and quality to changed economic conditions. It is motivated by the casual observation that in some instances firms adjust price without varying quality, while in other instances vary quality without adjusting price. For example during and following renovations (which lowers then raises the ease and enjoyment of shopping) a retailer does not change price. However the same retailer may have a post-Christmas sale with a given store configuration. A restaurant that becomes popular allows service standards (longer waits for a table, busier and less attentive waiting staff, more crowding) to fall rather than raise price. The same restaurant may offer discounted meals at lunchtimes or quiet nights.

Breakfast cereals are offered as ‘20% more at no extra cost’, yet later the price of the standard box is adjusted for inflation.

It is well known now that price does not always change to clear markets (Carlton 1989 and Blinder et. al. 1998). These examples suggest that quality may adjust to clear the market when price doesn’t, and visa versa. Alternatively neither may change, leaving the entire burden of adjustment on quantity.

The classic (full information) treatments of choice of quality by a monopolist is Spence (1975)[1], which in turn builds on (among others) Dorfman and Stiener (1954) and Swan (1970). In its full generality, the Spence model does not provide unambiguous predictions about the impact of shocks on quality. When buyer utility is separable in quantity and quality, the monopolist will choose inputs to minimise the cost of a unit of quality. In this case a shock will, by and large, cause a change in both price and quality. When, in addition, the marginal cost and the marginal unit cost of quality are constant[2], quality is invariant to demand shocks.[3] However, even under this assumption, any change to marginal cost should cause *both* a change in price and quality, a prediction at variance with the above casual observations.

To explain these observations, this paper utilises the methodology developed by Sibly (2002). It extends the Spence model so that customers’ utility is postulated to not only depend on the quantity and quality of the good consumed, but on also on their

[1] see also Sheshinski (1976)

[2] When the marginal unit cost of quality is constant, quality can be interpreted as having the properties of a private good. That is, quality is attached to the good (such as the quality of a restaurant meal) rather than the entire output (such as the quality of a road).

[3] This result is an implication of the Swan Invariance principle. See Sibly (2002) for a demonstration of this result.

disposition to the firm.[4] When customers' utility depends on the level of disposition, the firm's demand curve depends on price, quality and disposition. A decrease in disposition causes some customers to either change suppliers, leave the market or to purchase less frequently.

There are a number of plausible theoretical justifications for the postulate that customers' utility depends on disposition. From a psychological perspective, one reason is simply that social relationships are important to human beings. The strength of the social relationship between a firm and its customers will affect the latter's disposition and hence their willingness to buy from that firm. Secondly, Thaler (1991) argues that two 'kinds' of utility can be associated with the purchase of a good. He calls the first 'acquisition utility', which represents the value of the good relative to its price. This is the usual notion of utility used by economists. In addition Thaler argues that any purchase is also characterised by a 'transaction utility'. This component of utility measures the 'merits of deal': it would be expected to be influenced by the disposition of the customer to the firm. Thirdly, Okun (1981) offers another mechanism by which utility depends on customer disposition that is more within the economics tradition. He argues that ongoing relationships develop between firms and customers so that the latter can economise on search and transaction costs. An 'implicit contract' between firms and customers results, under which the firm agrees to set stable and fair prices. The level of disposition measures the customer's perception of their 'contract' with their firms.

---

[4] Disposition might be thought of as a firm's goodwill. However goodwill, as used by accountants, refers to *all* of a firm's intangible assets. The term 'disposition' is preferred in this paper because it refers specifically to the disposition of customers to the firm.

Customer disposition will influence firm's demand whether or not customers make repeat-purchases. When customers do not make repeated purchases, their disposition arises from the reputation, in particular the standing in the community, of the firm. When customers do make repeated purchases, disposition will reflect both the customer's personal experiences with the firm and its reputation

The firm's pricing and quality decisions are assumed to be the determinants of customer's disposition to the firm because they represents the 'terms of trade' between customers and the firm. In line with recent psychological research (Tversky and Kahneman, 1991) and marketing literature (Monroe, 1990 and Rajendran 1999), it is assumed that each customer's perception of price and quality is 'reference dependent': customers judge price and quality relative to a reference price and reference quality level. The reference price and reference quality level act a benchmark against which the actual price and quality are compared to determine disposition.

Psychological research indicates that the reference price and quality is determined by how the purchase is posed, or 'framed', in customers' minds (see for example Tversky and Kahneman, 1986). Experiments have indicated that peoples' reference levels typically represent either the 'status quo' or, alternatively, their view of a 'fair' outcome (Kahneman, Knetsch, and Thaler, 1991). Although these need not be the same thing, Kahneman et. al. (1986 p. 730-1) note that people eventually "adapt their views of fairness to the norms of actual behavior". Thus, with time, the status quo becomes to be perceived as fair 'because it is normal, not necessarily because it is just'. It is assumed therefore that the reference price and reference quality level are given by the existing price and quality level.

In calculating their disposition to the firm, customers may be particularly antagonised by losses (ie price increases or quality decreases) relative to the reference levels. In this case customers exhibit ‘loss aversion’ (Tversky and Kahneman, 1991). Loss aversion refers to a situation in which a loss to an economic agent relative to their reference level is weighted more heavily in the calculation of utility than a gain of equal magnitude. There have been a considerable number of experimental and empirical findings supporting the existence of loss aversion in a variety of contexts (see Kahneman, Knetsch and Thaler, 1991, for a survey).

Loss aversion creates a kink in each customer’s demand function at the reference price and quality. An increase in price (or a decrease in quality) relative to the reference level causes a decrease in each customer’s demand that is greater in magnitude than the increase following an equivalent decrease in price (or increase in quality). Consequently the firm faces a similar kink in its demand function.[5] It is demonstrated in this paper that there is a there is a range of demand or marginal cost that is consistent with a profit-maximising firm setting a given reference price and reference quality level. Consequently prices and quality are rigid in response to certain demand and cost shocks when customers exhibit loss aversion. In addition, however, it is shown that some shocks will cause a price adjustment but not quality adjustment, while other shocks result in quality adjustment without price adjustment. In this way firms adjust to the shock without imposing two ‘losses’ on customers. The model is therefore consistent with the casual observation described above.

[5] This behaviour is consistent with the notion that customers punish firms for acting unfairly by setting unfair price and quality levels. The idea that agents act in a retaliatory manner to unfairness has been supported by considerable experimental evidence. See Fehr and Gächter (2000) for a survey of this work.

The model is also used to consider the efficiency of the firm. It is shown that, when the firm has a kinked demand function, there is a set of reference price and reference quality levels that are efficient. As with the monopoly case, the efficient price and quality level may not change in response to changed economic conditions. On the other hand, to maintain efficiency following changed economic conditions, a change in price alone or quality alone may be required.

The case in which the firm is a natural monopoly is also considered. The Ramsey price and quality levels are determined by a zero profit constraint. There are a range of constrained (Ramsey) efficient price and quality levels. Optimal adjustment to satisfy the zero profit constraint may require a change in price alone, and change in quality alone, or a change in both price and quality. Which of these outcomes occurs depends on the reference price and quality levels. These are likely to be the historically set price and quality levels. Thus the historical level of price and quality will be important when determining the efficient price and quality for a regulated firm, such as a public utility.

The treatment of quality differs in emphasis from the literature concerning the choice of quality by a monopolist under perfect information (Schmalensee, 1979). Rather than consider how the profit maximising and efficient price and quality adjust to a change in economic conditions, this literature is primarily concerned with how the provision of quality by a monopolist is influenced by regulation.

Much of the modern literature focuses on the impact of asymmetric information on quality. However in the examples cited above information is symmetric across agents. Asymmetric information is therefore not responsible for the price and quality responses of the firm. Furthermore the paper is concerned with exploring the implications of loss aversion for price and quality setting in the least complicated setting. Therefore the model presented in this paper assumes agents have full information.

The paper proceeds as follows. Section 1 introduces the representative consumer model. Section 2 considers the firm's profit maximising level of price and quality. The efficient level of price and quality is determined in section 3. Ramsey price and quality levels are presented in section 4. Section 5 concludes the paper.

## 1. The Representative Consumer and Firm

The representative consumer gains utility from consuming n goods (see Dixit and Stiglitz 1977, Spence 1976). A representative consumer model is chosen explicitly to avoid considering the complicating issues of strategic interaction between firms and therefore to allow a focus on the role of loss aversion. It is assumed the consumer's utility function has the CES form:

$$U(x_1,..,x_n,s_1,..,s_n) = \sum_{i=1}^{n}[\alpha_i(g_i s_i^{\sigma} x_i)^{\rho}]^{1/\rho} \qquad (1)$$

where $x_i$ is the consumer's consumption of good, where i, i=1,..,n, $s_i$ is the quality or service level per unit of good i, $g_i$ measures the disposition to the firm which produces good i and $\alpha_i>0$ is a weight.[6] The goods are assumed to be substitutes so that $\rho<0$. Let $y_i= s_i^{\sigma}x_i$ be the quality adjusted consumption of good i. For a given level of disposition, it can be shown that $\sigma$ is the elasticity of substitution between quality and quantity in $y_i$.[7] It

[6] Using Thaler's (1991) interpretation, the contribution to utility of good i, $(g_i s_i^{\sigma} x_i)^{\rho}$, can be thought of as consisting of acquisition utility $(s_i^{\sigma} x_i)^{\rho}$ and transaction utility $g_i^{\rho}$ .
[7] From (5) below $y_i = (\alpha_i^{\eta} g_i^{\eta-1} \hat{p}^{\eta-1} I)s_i^{\sigma\eta} /p_i^{\eta}$. The elasticity of substitution is therefore $\sigma$.

is assumed that $\sigma>0$, and thus quantity and quality are substitutes. The household budget constraint is:

$$\sum_{i=1}^{n} p_i x_i = I \tag{2}$$

where $p_i$ is the price of good i and I is consumer income.

Disposition depends the value of price relative to its reference level and the value of quality with respect to its reference level. Specifically:

$$g_i = (p_i / p_i^R)^{-\mu_i} (s_i / s_i^R)^{\nu_i} \tag{3}$$

where $p_i^R$ is the reference price level of good i and $s_i^R$ is the reference quality level of good i. Loss aversion is captured by assuming:

$$\mu_i = \begin{cases} \lambda_1 & \text{if } p_i > p_i^{REF} \\ \lambda_2 & \text{if } p_i < p_i^{REF} \end{cases} \tag{4a}$$

and:

$$\nu_i = \begin{cases} \lambda_2 & \text{if } s_i > s_i^{REF} \\ \lambda_1 & \text{if } s_i < s_i^{REF} \end{cases} \tag{4b}$$

where $\lambda_1 > \lambda_2$. Loss aversion is absent if $\lambda_1 = \lambda_2$.

Before proceeding with the analysis, the reasons for restricting the functional forms of the utility and disposition functions are stated. The specific functional form for the utility function, (1), and for disposition (3) are chosen for the following reasons:

(i) Tversky and Kahneman, (1991) argue that an iso-elastic formulation, such as (3), is consistent with their experimental findings.

(ii) These functional forms allow a tractable mathematical analysis and a graphical analysis.

(iii) Iso-elastic functional forms allow an economic analysis to be undertaken while holding the value of a fundamental concept (elasticity) constant.

(iv) It is shown that, without loss aversion, quality is rigid with respect to demand shocks. This is consistent with the standard approach in economics that excludes consideration of quality, and thus highlights the impact of loss aversion.

(v) With fully general functional forms it is not possible to tell whether an increase in demand increases or decreases quality. This formulation takes a 'neutral stance' on this ambiguity.

Households are price and quality takers, and thus treat $p_i$, $s_i$ and $g_i$ as exogenous. They maximise utility, (1), subject to the budget constraint (2). Household demand for good i is therefore:

$$x_i(p_i,q_i) = \alpha_i^{\eta}(g_i s_i^{\sigma})^{\eta-1}\hat{p}^{\eta-1}\, I/p_i^{\eta} \qquad (5)$$

where the consumer's price index, $\hat{p}$, is given by:

$$\hat{p}=\left(\sum_{k=1}^{n}\alpha_k^{\eta}(p_k/g_k s_k^{\sigma})^{1-\eta}\right)^{\frac{1}{1-\eta}} \qquad (6)$$

where $\eta \equiv 1/1\text{-}\rho>1$ is the elasticity of substitution. As n is assumed large, $\hat{p}$ will be assumed independent of changes in $p_i$ alone. Without loss of generality it is assumed that

$$\sum_{k=1}^{n} \alpha_k^{\eta} = 1.$$

By substituting the expression for disposition (3) into (5), demand for good i can be written as:

$$x_i(p_i,s_i,p_i^R,s_i^R) = A_i p_i^{-\eta} s_i^{\sigma(\eta-1)} (p_i/p)^{-\mu_i(\eta-1)} (s_i/s_i^R)^{\nu_i(\eta-1)}$$

$$= A_i(p_i^R,s_i^R) p_i^{-\phi_i} s_i^{\kappa_i} \quad (7)$$

where $A_i(p_i^R,s_i^R) = \alpha_i^{\eta}\hat{p}^{\eta-1}(p_i^R)^{\mu_i(\eta-1)}(s_i^R)^{-\nu_i(\eta-1)}$ I, $\phi_i=\eta(1+\mu_i)-\mu_i$ and $\kappa_i=(\eta-1)(\sigma+\nu_i)$. The demand function, (7), will be that faced by firm i.

The demand function (7) is kinked at the reference price and quality. It is basis of the analysis below. Those readers who were interested in the implications of a kink demand function, which arises for reasons other than loss aversion, could interpret the following analysis beginning with (7).

## 2. Profit Maximising Price and Quality

The cost of providing a unit of good i with quality level $s_i$ is assumed to be $\chi s_i$, where $\chi$ is the (constant) cost a unit of quality. As the cost of quality varies with output, this assumption suggests that the quality is embodied in each unit of output. Thus quality has the property of a private good. The profit of firm i, $\pi_i$, is given by:

$$\pi_i(p_i,s_i,p_i^R,s_i^R) = (p_i - c - \chi s_i) x_i (p_i,s_i,p_i^R,s_i^R) \quad (8)$$

where c is the (constant) marginal cost of production. The firm chooses price and quality to maximise profit. When price is chosen to maximise profit, holding quality constant, it satisfies:

$$p_i = \begin{cases} p_2(s_i) \text{ if } p_i^R > p_2(s_i) \\ p_i^R \text{ if } p_1(s_i) \leq p_i^R \leq p_2(s_i) \\ p_1(s_i) \text{ if } p_i^R < p_1(s_i) \end{cases} \tag{9}$$

where $p_j(s_i) = \theta_j(c+\chi s_i)$ and $\theta_j=\frac{(\eta-1)(1+\lambda_j)+1}{(\eta-1)(1+\lambda_j)}>1$. When quality is chosen to maximise profit, holding price constant, it satisfies:

$$s_i=\begin{cases} s_1(p_i) \text{ if } s_i^R>s_1(p_i) \\ s_i^R \text{ if } s_2(p_i) \leq s_i^R \leq s_1(p_i) \\ s_2(p_i) \text{ if } s_i^R< s_2(p_i) \end{cases} \tag{10}$$

where $s_j(p_i)=\frac{p_i-c}{\xi_j\chi}$ and $\xi_j = \frac{(\eta-1)(\sigma+\lambda_j)+1}{(\eta-1)(\sigma+\lambda_j)} > \theta_j > 1$. The profit maximising price and quality satisfies both (9) and (10).

**Model without loss aversion**

To aid in the interpretation of later results, consider the model in which loss aversion is absent, ie in which $\lambda_1= \lambda_2=\lambda$. In this case, from (9), the profit maximising price of firm i for a given level of quality, $p_i^*(s_i)$, satisfies:

$$p_i^*(s_i) =\theta(c + \chi s_i) \tag{11}$$

where $\theta = \frac{(\eta-1)(1+\lambda)+1}{(\eta-1)(1+\lambda)}$. Equation (11) indicates that price is a mark-up, θ, over total marginal cost, $c + \chi s_i$. This result is a consequence of the assumption of constant elasticity of demand and constant marginal cost. The profit maximising quality of firm i for a given price, $s^*_i,(p_i)$ satisfies:

$$s^*_i(p_i) = \left(\frac{p_i - c}{\chi\xi}\right) \qquad (12)$$

where $\xi = \frac{(\eta-1)(\sigma+\lambda)+1}{(\eta-1)(\sigma+\lambda)}$. By substituting (11) into (12) the profit maximising price is:

$$p^*_i = \frac{(\eta+\lambda(\eta-1))c}{(\eta-1)(1-\sigma)} \qquad (13)$$

and profit maximising quality is:

$$s^*_i = \frac{(\sigma+\lambda)c}{\chi(1-\sigma)} \qquad (14)$$

As the reference price enters the demand function multiplicatively, it does directly determine the profit maximising price and quality. However, the impact on demand of the price level relative to its reference level is captured by the term λ in (13) and (14).

The solution to the model without loss aversion is depicted in figure 1. Figure 1 shows various iso-profit curves $\pi_1$, $\pi_2$, $\pi_3$, and the lines $p^*_i(s_i)$ and $s^*_i(p_i)$. The maximum profit level occurs at the point, $\pi^*_i$, where the lines $p^*_i(s_i)$ and $s^*_i(p_i)$ intersect. This figure will be used late in the paper to compare the profit maximising price and quality with the efficient and constrained efficient.

It is readily seen from (13) and (14) that an increase in marginal cost of production, c, increases the price and quality of good i. (The $p^*_i(s_i)$ curve in figure 1 is shifted up by a greater amount than the $s_i^*(p_i)$ curve.) Indeed the elasticity of price and quality with respect to marginal cost is 1. Intuitively an increase in marginal cost causes an increase in price, causing customers to reduce quantity demanded. As quantity and quality are substitutes, there is an increase demand for quality. The elasticity of quality with respect to its cost is –1. An increase in the cost of quality causes an equal proportional decrease in the demand for quality, leaving total marginal cost unaffected. There is therefore no increase in price following an increase in the cost of quality. The elasticity of price with respect to $\sigma$ is $\sigma/1-\sigma$, while the elasticity of quality with respect to $\sigma$ is $\sigma(1+\lambda)/(\sigma+\lambda)(1-\sigma)$. Intuitively an increase in the substitutability of quantity and quality allows the firm to raise price by also raising quality.

An increase in demand can be modelled in at least two ways: as an increase in income or a decrease in the elasticity of demand. Because of the iso-elastic nature of demand, and the presence of constant marginal cost, neither price nor quality change when there is a change in income.

In the textbook model of monopoly, when marginal cost is constant, an increase in demand only increases price when it is associated with a decrease in the elasticity of demand. Thus when considering how to model an increase in demand in the above model it is appropriate to consider a decrease in the elasticity of demand. From (13) and (14) a decrease in the elasticity of demand increases price but does not affect quality. Observe that a decrease in the elasticity of demand occurs when there is a decrease in $\eta$, the elasticity of substitution between good i and other goods. As goods are less perfect substitutes for one another the markets are less competitive. As firms have more market power this enables them to raise price. Observe that the decrease in $\eta$ does not change the customers' substitutability of the quantity of good i for its quality, thus does not change the profit maximising level of quality.

The case without relativities with respect to reference prices is considered by Spence (1975). It can be retrieved by setting $\lambda=0$. It is readily observed that the model with relativities (but without loss aversion) is qualitatively similar to that without relativities (especially in regard to the comparative statics). In particularly, the models both predict a price and quality response any change in marginal cost, no matter how small that change is. Furthermore in both models changes in the elasticity of demand leave quality unaffected. Thus little new is added by the introduction of 'relativities' per se. This conclusion changes with the addition of loss aversion

**Model with loss aversion.**

The solution to equations (9) and (10) depend on the value of the reference price and quality when $\lambda_1 > \lambda_2$. An example, with assumed values the reference price and quality, is shown in figure 2. The lines $p_1(s_i)$, $p_2(s_i)$ $s_1(p_i)$ and $s_2(p_i)$ are drawn in figure 2. These are used to depict the equation for the profit maximising choice of price, (10), and the profit maximising choice of quality (11). These functions are shown as the bold lines in figure 2. The profit maximising price and quality occur where the two bold lines intersect. In this particular example the profit maximising price is the reference price, while the profit maximising quality is $s_i^*$.

The analysis of figure 2 can determine the profit maximising price and quality for any given the reference price and quality. Using this analysis for every combination of reference price and quality yields figure 3. In figure 3 the (s,p) plane is divided into nine regions. Each region indicates a different relationship between the reference price and quality and the profit maximising price and quality. This relationship is indicated by the name of the region. The first letter indicates the relationship between the profit max price and the reference price, while the second letter indicates the relationship between the profit maximising level quality and the reference level of quality: E indicates the reference level equals the profit maximising level, A indicates that the profit maximising level is above the reference level and B indicates the profit maximising level is below the reference level.

The region labelled EE is bounded by the lines $p_1(s_i)$, $p_2(s_i)$ $s_1(p_i)$ and $s_2(p_i)$. The intersection of the lines $p_j(s_i)$ and $s_k(p_i)$ occurs at points labelled $V_{jk}$ in figure 3. Algebraically the points $V_{jk}$ are given by:

$$p_i = \frac{(\eta+\lambda_j(\eta-1))c}{(\eta-1)(1-\sigma+\lambda_j-\lambda_k)} \tag{15}$$

and:

$$s_i = s_{i,jk} \equiv \frac{(\sigma+\lambda_k)c}{\chi(1-\sigma+\lambda_j-\lambda_k)} \tag{16}$$

If the reference price and quality lie in the region labelled EE they are the profit maximising levels of price and quality. When the reference price and quality lie in one of the other eight regions, the profit maximising level of price and quality lie on the boundary of the EE region. The reference price and quality depicted in figure 2 lie in the EB region. The profit maximising price and quality lie on the right hand side boundary of the EE region, with the profit maximising price equal to the reference price. If the reference level of price and quality lies in the AB region, the profit maximising price and quality occurs that the intersection of the $p_1(s_i)$ and s1(pi) curves, ie on corner of the EE region labelled $V_{11}$.

Figure 3 enables a comparative statics analysis. To undertake this analysis it is necessary to specify an initial configuration of the model, particularly with respect to the reference price and quality. To this end, define an equilibrium price as occurring when the reference price equals the actual price, and equilibrium quality as occurring when the reference quality equals the actual quality. Clearly an equilibrium price and quality must lie in the region EE. For comparative statics exercises assume that initially the firm sets the equilibrium price and quality.

Consider an increase in c, the marginal cost of the firm. From (15) and (16) each of the four vertices of EE, $V_{jk}$, shifts in a north-east direction in figure 3. Therefore the entire region EE also shifts in that direction. The reference price will lay in one the (new) regions EE, AE, AA or EA, depending on the position of the reference point and the extent of the shift. If the shift is sufficiently small, the reference point will lie in the interior of EE. In this event price and quality will be rigid in response to the cost increase. If the shift leaves the reference point in the region EA (as might be the case if the reference quality was relatively low), the response of the firm is to raise quality but maintain price. If the shift leaves the reference point in the region AE (as might be the case if the reference price was relatively low), the response of the firm is to raise price but maintain quality. The firm only adjusts both price and quality, as would be the case in the absence of loss aversion, if the cost increase places the reference point in the region AA.

Consider an increase in demand, which as noted above, is modelled by a decrease in the elasticity of demand. From (15) and (16) the vertices of EE move vertically upward. As with the cost increase, the reference price will lay in one the (new) regions EE, AE, AB or EB, depending on the position of the reference point and the extent of the shift. The increase in demand could therefore result in no change of price and quantity (reference point remain in EE), a maintenance of price and reduction in quality (reference point in EB) or an increase in price and reduction in quality (reference point in AB). The firm only adjusts price and maintains quantity, as would be the case in the absence of loss aversion if the demand increase places the reference point in the region AE.

An increase in the substitutability of quantity and quality or a shift in the cost of quality can also be analysed in the above way. Each can result in no change of price and, a reduction in quality but maintenance of price, an increase in price and no change in quality, or an increase in price and reduction in quality. Again, the variety of profit maximising responses stands in contrast to the conclusions when loss aversion is absent.

To conduct the above comparative static analysis it is assumed that the reference levels are unaffected by the shock. However in some instances the reference levels may shift with a change in one of the exogenous variables. For example, in a survey conducted by Kahneman, Knetsch and Thaler (1986), it was found that customers thought it was “unfair to exploit shifts in demand by raising price”. On the other hand, customers thought it acceptable to increase price when cost increased. A similar outcome is conceivable with respect to quality, although Kahneman, Knetsch and Thaler (1986) consider only price changes. In any event, this finding suggests the possibility that customers will change their reference levels in line with observed cost changes, but will not change their reference point in line with demand shocks. The economics of this possibility is considered in detail by Sibly (2002). The above analysis can be readily extended to incorporate this possibility by simply assuming that reference point shifts, along with the regions in figure 3, following the shock.

## 3. Efficient Prices and Quality

In this section the efficient price and quality are determined, and compared with the profit maximising price and quality. The efficient price and quality maximise the social surplus. The social surplus arising from the consumption of good i is given by the sum of consumer surplus, $CS_i$, and profit of firm i:

$$S_i(p_i,s_i) = CS_i(p_i,s_i) + \pi_i(p_i,s_i) \qquad (17)$$

where, from (7):

$$\pi_i(p_i,s_i)= A_i(p_i-c-\chi s_i)\, p_i^{-\phi_i} s_i^{\kappa_i} \qquad (18)$$

Consumer surplus is given by:

$$CS_i(p_i,s_i) = (\ln\hat{p}_{-i} - \ln\hat{p})I \qquad (19)$$

where $\hat{p}_{-i}=\left(\sum_{k\neq i}^{n}\alpha_k^{\eta}(p_k/g_k s_k^{\sigma})^{1-\eta}\right)^{\frac{1}{1-\eta}}$ and $g_i$ is given by (3). The social surplus provides a good approximation of welfare when income effects can be treated as negligible, in particular when $p_i x_i$ is a small fraction of users' income (see Tirole, 1988, p. 11).

When price is chosen to maximise the social surplus, holding quality constant, it satisfies:

$$p_i = \begin{cases} p_2(s_i) \text{ if } p_i^R > p_2(s_i) \\ p_i^R \text{ if } p_1(s_i) \leq p_i^R \leq p_2(s_i) \\ p_1(s_i) \text{ if } p_i^R < p_1(s_i) \end{cases} \quad (20)$$

where $p_j(s_i)=\upsilon_j(c+\chi s)$ and $\upsilon_j=\left(\frac{\eta(1+\lambda_j)-\lambda_j}{\eta(1+\lambda_j)}\right)<1$. When quality is chosen to maximise the social surplus, holding price constant, it satisfies:

$$s_i=\begin{cases} s_1(p_i) \text{ if } s_i^R > s_1(p_i) \\ s_i^R \text{ if } s_2(p_i) \leq s_i^R \leq s_1(p_i) \\ s_2(p_i) \text{ if } s_i^R < s_2(p_i) \end{cases} \quad (21)$$

where $s_j(p_i)=\varpi_j\left(\frac{\eta(p_i-c)+c}{\chi}\right)$ and $\varpi_j=\frac{(\sigma+\lambda_j)}{(\eta-1)(\sigma+\lambda_j)+1}$. There is a clear analogy between the simultaneous conditions for efficiency, (20) and (21), and the simultaneous conditions for profit maximisation (9) and (10). Therefore the analysis of efficiency below follows the approach of the case of profit maximisation.

**Model without loss aversion**

Consider the model in which loss aversion is absent, ie in which $\lambda_1=\lambda_2=\lambda$.. In this case, from (20), the efficient price of firm i satisfies:

$$p_i^e(s_i) = \upsilon(c+\chi s_i) \quad (22)$$

where $\upsilon = \left(\frac{\eta(1+\lambda)-\lambda}{\eta(1+\lambda)}\right) < 1$. As marginal cost is given by $c+\chi s_i$, equation (22) indicates that the efficient price is below marginal cost. Thus, when operating efficiently, the firm makes a loss. Intuitively this is due to the effect of relativities: customers' willingness to pay is increased as price is lowered relative to the reference price. This intuition is confirmed by setting $\lambda=0$, which removes the effect of relativities. Then, as $\upsilon=1$, equation (22) is the familiar condition that price equals marginal cost. From (21) the efficient quality of firm i satisfies:

$$s_i^e(p_i) = \varpi\left(\frac{\eta(p_i-c)+c}{\chi}\right) \qquad (23)$$

and $\varpi = \frac{(\sigma+\lambda)}{(\eta-1)(\sigma+\lambda)+1}$. Therefore the efficient price, $p_i^e$, is:

$$p_i^e = \frac{(\eta+\lambda(\eta-1))c}{\eta(1-\sigma)} \qquad (24)$$

and the efficient quality, $s_i^e$, is:

$$s_i^e = \frac{(\sigma+\lambda)c}{\chi(1-\sigma)} \qquad (25)$$

Observe that from (25) and (14) $s_i^e = s_i^*$. That is, in the absence of loss aversion, the efficient level of quality is equal to the profit maximising level of quality. Thus the point representing efficiency in figure 1, $\pi_i^e$, lies directly below, $\pi_i^*$, the point representing profit maximisation. This result recalls Swan's Invariance principle. It is the consequence of the assumption that customer utility is separable and the marginal cost and the marginal unit cost of quality are constant.[8] The result (25) indicates this principle extends to a utility function of the form (1), even in the presence of relativities.

**Model with loss aversion**

The set of efficient prices and qualities are shown in figure 4. These are derived in an analogous manner to those in figure two, and are also defined analogously. For example, if the reference level of price and quality lie in the region *EE*, then the reference price and quality are efficient. Furthermore, if the reference price and quality lie in the *EB* region, then the efficient price and quality lie on the right hand side boundary of the *EE* region, with the efficient price equal to the reference price.

Also by analogy to the analysis in the previous section, the corners of the region EE, $V_{jk}$, are useful for conducting comparative statics exercises. Algebraically the points $V_{jk}$ are given by:

$$p_i = \frac{(\eta+\lambda_j(\eta-1))c}{\eta(1-\sigma+\lambda_j-\lambda_k)} \qquad (26)$$

and:

$$s_i = s_{i,jk} \qquad (27)$$

A comparative statics exercise can be conducted on the corners, $V_{jk}$, as was done above (in the profit maximising case), to indicate how the efficient price and quality should be changed in response to demand and cost changes.

[8] See Sibly (2002).

A comparison of (15) and (16) with (26) and (27) indicate that the corners of the efficient region *EE* of lie vertically below the corners of the profit maximising region EE. Points in the profit maximising region EE lie in the efficient regions *BE*, *BA* or possibly *EA*. Consider a firm setting an equilibrium price and quality. To move the firm to an efficient price and quality it is necessary to either (i) lower price if the equilibrium price is in the region *BE* or (ii) lower price and raise quality if the equilibrium price is in the region *BA* or (iii) raise quality if the equilibrium price is in the region *EA*.

## 4. Ramsey Price and Quality

Equation (22) indicates that firms will make a loss under efficient pricing. Such a loss would be exacerbated if firms also face a fixed cost, F. If the firm is required to 'break even' the (constrained) social optimal price and quantity satisfy the following:

$$\max_{p_i,s_i} \; S_i(p_i,s_i) \text{ subject to } \pi_i(p_i,s_i) = F \qquad (28)$$

Conventional Lagrangian methods cannot be used to analyse (28) because of the non-differentiability of both the objective function and the constraint. Rather a graphical approach will be used.

A price and quality level which satisfies the profit constraint will also satisfy (28) if it also satisfies the following 'extended tangency condition'. That is, the slope of the iso-profit curve is greater than the slope of the iso-surplus curve for price increases, and the slope of the iso-profit curve is less than the slope of the iso-surplus curve for price decreases. Mathematically this is equivalent to:

$p_i^*$ and $s_i^*$ satisfy (28) if, when $p_i = p_i^*$ and $s_i = s_i^*$,

$$\left.\frac{dp_i}{ds_i}\right|_{CS_i \text{ constant}} < \left.\frac{dp_i}{ds_i}\right|_{\pi_i=F} \text{ if } p_i > p_i^* \text{ and } s_i > s_i^* \quad (29)$$

and:

$$\left.\frac{dp_i}{ds_i}\right|_{CS_i \text{ constant}} > \left.\frac{dp_i}{ds_i}\right|_{\pi_i=F} \text{ if } p_i < p_i^* \text{ and } s_i < s_i^* \quad (30)$$

This is depicted in figure 5 for the case in which $p_i^* = p_i^R$ and $s_i^* = s_i^R$. Taking the total derivative of (18), the slope of iso profit curve is given by:

$$\left.\frac{dp}{ds}\right|_{\pi_i=F} = \frac{\chi-(p_i-c-\chi s_i)\,(\eta-1)(\sigma+\nu_i)/s_i}{1-(p_i-c-\chi s_i)(\eta(1+\mu_i)-\mu_i)/p_i} \quad (31)$$

Taking the total derivative of (19), the slope of iso consumer surplus curve is given by:

$$\left.\frac{dp}{ds}\right|_{CS_i \text{ constant}} = \frac{(\sigma+\nu_i)p_i}{(1+\mu_i)s_i} \quad (32)$$

**Model without loss aversion**

In the absence of loss aversion, from (31), the slope of iso-profit curve is given by:

$$\left.\frac{dp}{ds}\right|_{\pi_i=F} = \frac{\chi-(p_i-c-\chi s_i)\,(\eta-1)(\sigma+\lambda)/s_i}{1-(p_i-c-\chi s_i)(\eta(1+\lambda)-\lambda)/p_i} \qquad (33)$$

while, (32), the slope of iso-consumer surplus curve is given by:

$$\left.\frac{dp}{ds}\right|_{CS_i\text{ constant}} = \frac{(\sigma+\nu_i)p_i}{(1+\mu_i)s_i} \qquad (34)$$

Equating the slope of the iso-profit and iso-consumer surplus curves gives:

$$s_i == \frac{(\sigma+\lambda)c}{\chi(1-\sigma)} \qquad (35)$$

The points of tangency between the iso-profit and iso-consumer surplus curve, (35), represent the contract curve. It is the line, in figure 1, connecting the point of profit maximisation, $\pi_i^*$, and the efficient point, $\pi_i^e$. The line is vertical, indicating that the optimal constrained choice quality is independent of F.

**Model with loss aversion**

If the firm sets price and quality equal to the reference price, there are three possible outcome: (i) the firm breaks even, ie $\pi_i(p_i^R,s_i^R) = F$, (ii) the firm makes a loss, ie. $\pi_i(p_i^R,s_i^R) < F$, and (iii) the firm makes a profit ie. $\pi_i(p_i^R,s_i^R) > F$. These three possibilities are considered in turn below:

<u>(i) $\pi_i(p_i^R,s_i^R) = F$.</u> In this case the profit constraint is clearly satisfied if the firm sets price and quality equal to their reference level. Then $p_i^R$ and $s_i^R$ will be a constrained maximum

if they satisfy the extended tangency condition as depicted in figure 5. From (29) and (30) the extended tangency condition holds when $p_i^* = p_i^R$ and $s_i^* = s_i^R$ if:

$$s_{i,12} < s_i < s_{i,21}.$$

Thus if the reference point lie along the bold section of the line $\pi_i(p_i^R, s_i^R) = F$ in figure 5, it represents a constrained optimal price and quality. Note that, in contrast to the case with no loss aversion, there is a continuum of such points.

(ii) $\pi_i(p_i^R, s_i^R) < F$. In this case the firm makes a loss when it sets the reference price and quality. To graph this situation, define $p_i^F$ by $\pi_i(p_i^F, s_i^R) = F$ and $s_i^F$ by $\pi_i(p_i^R, s_i^F) = F$. The iso-profit curve has a kink at the points $\pi_p^F = (p_i^F, s_i^R)$ $\pi_s^F = (p_i^R, s_i^F)$. An isoprofit curve is depicted in figure 6.

It can be observed from figure 6 that there are five possibilities locations for tangency with the iso-consumer surplus curve on the iso-profit curve:

(i) To the right of $\pi_p^F$: In this case $p_i > p_i^R$, $s_i > s_i^R$. The extended tangency condition implies $s_i = s_{i,12}$

(ii) At the point $\pi_p^F$: In this case $p > p_i^R$, $s = s_i^R$. Using (31) and (32), the extended tangency condition implies $s_{i,12} < s_i < s_{i,11}$.

(iii) Between the point $\pi_p^F$ and $\pi_s^F$: In this case $p > p_i^R$, $s < s_i^R$. The extended tangency condition implies $s_i = s_{i,11}$.

(iv) At the point $\pi_s^F$: In this case $p = p_i^R$, $s < s_i^R$,. The extended tangency condition implies $s_{i,11} < s_i < s_{i,21}$.

(v) To the left of $\pi_s^F$: In this case $p < p_i^R$, $s < s_i^R$. The extended tangency condition implies $s_i = s_{i,21}$.

An example of the relationship between the reference price and quality levels and the lines $s_{i,12}$, $s_{i,11}$ and $s_{i,21}$ are depicted in figure 6. It is readily verified that only the point $\pi_s^F$ satisfies only condition (iv). In this case the optimal price is the reference price, and the optimal quality is $s_i^F$.

By considering the various possibilities of the location of the reference point relative to the lines $s_{i,12}$, $s_{i,11}$ and $s_{i,21}$ the following result is thereby obtained:

(i) If $s_i^F > s_{i,21}$ then $p_i$ and $s_i$ satisfy $s_i = s_{i,21}$ and:

$$\pi = A_i(p_i - c - \chi s_i)\, p_i^{-\eta(1+\lambda_2)+\lambda_2} s_i^{(\sigma+\lambda_1)(\eta-1)} (p_i^R)^{\lambda_2(\eta-1)} (s_i^R)^{-\lambda_1(\eta-1)} = F$$

(ii) If $s_{i,11} < s_i^F < s_{i,21}$ then $p_i = p_i^R$ and $s_i = s_i^F$

(iii) If $s_i^F < s_{i,11}$ and $s_{i,11} < s_i^R$ then $p_i$ and $s_i$ satisfy $s_i = s_{i,11}$ and:

$$\pi = A_i(p_i - c - \chi s_i)\, p_i^{-\eta(1+\lambda_1)+\lambda_1} s_i^{(\sigma+\lambda_1)(\eta-1)} (p_i^R)^{\lambda_1(\eta-1)} (s_i^R)^{-\lambda_1(\eta-1)} = F$$

(iv) If $s_{i,12} < s_i^R < s_{i,11}$ then $p_i = p_i^F$ and $s_i = s_i^R$

(v) If $s_i^R < s_{i,12}$ then $p_i$ and $s_i$ satisfy $s_i = s_{i,12}$ and:

$$\pi = A_i(p_i - c - \chi s_i)\, p_i^{-\eta(1+\lambda_1)+\lambda_1} s_i^{(\sigma+\lambda_2)(\eta-1)} (p_i^R)^{\lambda_1(\eta-1)} (s_i^R)^{-\lambda_2(\eta-1)} = F$$

<u>(iii) $\pi_i(p_i^R, s_i^R) > F$.</u> The derivation of the optimal price and quality in this case is similar to that above. For brevity the following statement of the optimal price and quality is given without derivation:

(i) If $s_i^R > s_{i,21}$ then $p_i$ and $s_i$ satisfy $s_i = s_{i,21}$ and:

$$\pi = A_i(p_i - c - \chi s_i)\, p_i^{-\eta(1+\lambda_2)+\lambda_2} s_i^{(\sigma+\lambda_1)(\eta-1)} (p_i^R)^{\lambda_2(\eta-1)} (s_i^R)^{-\lambda_1(\eta-1)} = F$$

(ii) If $s_{i,22} < s_i^R < s_{i,21}$ then $p_i = p_i^F$ and $s_i = s_i^R$ .

(iii) If $s_i^R < s_{i,22}$ and $s_{i,22} < s_i^F$ then $p_i$ and $s_i$ satisfy $s_i = s_{i,22}$ and:

$$\pi = A_i(p_i - c - \chi s_i)\, p_i^{-\eta(1+\lambda_1)+\lambda_1} s_i^{(\sigma+\lambda_1)(\eta-1)} (p_i^R)^{\lambda_1(\eta-1)} (s_i^R)^{-\lambda_1(\eta-1)} = F$$

(iv) If $s_{i,12} < s_i^F < s_{i,22}$ then $p_i = p_i^R$ and $s_i = s_i^F$

(v) If $s_i^F < s_{i,12}$ then $p_i$ and $s_i$ satisfy $s_i = s_{i,12}$ and:

$$\pi = A_i(p_i - c - \chi s_i)\, p_i^{-\eta(1+\lambda_1)+\lambda_1} s_i^{(\sigma+\lambda_2)(\eta-1)} (p_i^R)^{\lambda_1(\eta-1)} (s_i^R)^{-\lambda_2(\eta-1)} = F$$

## 5. Discussion

In the Spence model, there are smooth substitution possibilities between price and quality. The price and quality set by the profit maximising firm are therefore sensitive to most changes in economic conditions. For example an increase in marginal cost will change the profit maximising level of price and quality. This paper shows that the introduction of customer loss aversion changes this conclusion. To avoid an adverse reaction by consumers, firms will be reluctant to raise price and lower quality relative to their reference levels. An increase in marginal cost may therefore either have no effect on the level of price and quality, cause price to increase while maintaining quality, or cause quality to increase while maintaining price.

An implication of the above analysis is that firms will appear to be willing to bear 'losses' in order to maintain either price or quality in the face of an unexpected cost shock. This could account for the extraordinary actions of the Saturn motor company when, in 1991, it discovered that some of its new cars had been sold with the wrong coolant.[9] Rather than undertake the minimum repairs the company gave the customers an entirely new car. As the minimum level of repairs would satisfy the warranty requirements, this costly decision may not initially appear profit maximising. However in

[9] These events are recounted in Whitely and Hessan (1996 p. 221).

the light of the above analysis, it could be interpreted as the firm ensuring that customers receive (and expect to receive) their reference level of quality. In this way the decision is in fact profit maximising.

In some instances firms' marketing efforts could be interpreted as an attempt to influence customers' reference price and allow a smooth substitution of price and quality. For example when a firm advertises that it 'under new management', it is attempting to convince customers to not treat past price and quality as the status quo. If this strategy is successful, the new manager is able to vary price and quality without worrying about the impact of loss aversion.

Similarly, the introduction of 'new models' allows the firm to, at least partially, break the link with the past. Technological advances allow a firm improves the quality of its product. But the analysis in this paper indicates that, if the customers do not modify their reference prices, it may not be profit maximising to raise price. If it is costly to adopt the new technology, it will not therefore be profit maximising to improve the quality. The introducing of a new model may convince customer to adopt a new reference price, and thereby allow the improvement of quality.

The quality of a good, as perceived by customers, will usually have many characteristics. (For example, the quality of a restaurant may depend on the quality of its food and the ambience there.) When a firm introducing a new technology it is often not seen as unambiguously better. (For example modern technology may allow lighter more fuel-efficient cars, but some customers may mourn the loss of 'more solid cars'.) Indeed, even if the new product is technically superior, some customers may perceive it as inferior. Because of loss aversion, the reduction of particular characteristics may, in the mind of customers, not be offset by the gain in other characteristics. Again, the introduction of a new model may break the link with the past, allowing a smooth substitution across the characteristics that define quality.

The existence of loss aversion has important conclusions for the regulation of monopolies such as public utilities. Traditional analysis suggests that regulator can trade off price and quality. However the analysis of this paper suggests, it is necessary for regulators to take into account customer expectations when considering price or service adjustments. Consumer expectations are inevitably based on historical price and service levels. For example, a public transport system may be run at a loss, and it is decided it must 'break even'. If the system traditionally enjoyed a high service level and moderate price, the optimal actions may be to lower the service level alone. Offsetting the lowering of the service standard with an increased price would risk inefficiently increasing the dissatisfaction with the change. This result stands in contrast with the Swan Invariance result, which would be implied by the model in the absence of loss aversion.

In drawing efficiency conclusions, this paper has assumed that the true value of goods is given by the area under consumers' demand curve when disposition *is* taken into account. This is consistent with the standard approach in economics, where the social value of a good is simply consumers' valuation of it. However, some may argue that psychological effects that are captured by disposition should not be incorporated into a measure of the social value of a good. (Why should a social planner care whether the consumers are aggrieved by a price increase of an under-priced good?) In this case a welfare analysis would proceed as if disposition were a constant ($\lambda$=0), and the efficient outcomes would be those given by the Spence model.

## REFERENCES


Blinder, A.S., Canetti, E. Lebow, D., and Rudd, J. (1998), "Asking about Prices: A New Approach to Understanding Price Stickiness" Russell Sage Foundation, New York.

Carlton, D. (1986), "The Rigidity of Prices", *American Economic Review*, 76, pp. 637-658

Carlton, D. (1989), "The Theory and Facts of How Markets Clear: Is Industrial Organization Valuable for Understanding Macroeconomics", in R. Schmalensee and R.D Willig (ed) *The Handbook of Industrial Organization*, Vol 1, Elsevier pp. 910-946.

Dixit A. and Stiglitz, J. (1977), "Monopolistic Competition and Product Diversity", *American Economic Review*, 67, pp.297-308.

Dorfman, R. and Stiener P. O., (1954), "Optimal advertising and optimal product quality", *American Economic Review*, 44, pp.826-36.

Fehr, E. and Gächter, S., (2000), "Fairness and Retaliation: The Economics of Reciprocity", *Journal of Economic Perspectives*, V34, Number 3, pp.159-81.

Kahneman, D. Knetsch, J. and Thaler, R., (1986) "Fairness as a Constraint on Profit Seeking: Entitlements in the Market", *American Economic Review*, 74(4), pp. 728-741.

Kahneman, D. Knetsch, J. and Thaler, R., (1991) "The Endowment Effect, Loss Aversion, and Status Quo Bias: Anomalies", *Journal of Economic Perspectives*, 5(1), Winter, pp. 193-206.

Monroe, K. B. (1990), *Pricing: Making Profitable Decision*s, Second Edition, McGraw-Hill, Boston, Massachusetts.

Okun, A. M. (1981), *Prices and Quantities*, Brookings Institution, Washington DC.

Rajendran, K. N. (1999), "Reference Price" in P. E. Earl and S. Kemp (eds) *The Elgar Companion to Consumer Research and Economic Psychology*, Edward Elgar, Cheltenham UK, pp. 495-9.

Schmalensee, R., (1979), "Market Structure, Durability and Quality: A Selective Survey" *Economic Inquiry*, V. XVII, pp. 177-96.

Sheshinski, E., (1976), "Price, Quality and Quality Regulation in Monopoly Situations", *Economica*, 43, pp.127-37

Sibly, H. (2002), "Loss Averse Customers and Price Inflexibility", *Journal of Economic Psychology*, 23, pp. 521-38.

Sibly, H. (2002) "A Bargaining Model of Public Utility Quality when Preferences are Separable" mimeo, University of Tasmania

Spence, A.M. (1975), "Monopoly, quality and regulation", *Bell Journal of Economics*, pp. 417-429.

Spence, A.M. (1976), "Product Differentiation and Welfare", *American Economic Review*, 66, pp. 407-14.

Swan, P., (1970), "The durability of consumption goods", *American Economic Review*, pp.884-94.

Thaler, R. (1991), *Quasi Rational Economics*, Russell Sage Foundation, New York.

Tirole, J. (1988), *The Theory of Industrial Organization*, MIT Press, Cambridge, Massachusetts.

Tversky, A. and Kahneman, D., (1986) "Rational Choice and the Framing of Decisions", *Journal of Business*, 59, pp. S251-278.

Tversky, A. and Kahneman, D., (1991), "Loss Aversion in Riskless Choice: A Reference-Dependent Model", *Quarterly Journal of Economics*, pp. 1039-61.

Whiteley, R. and Hessan , D., (1996), *Customer Centered Growth*, Addison Wesley, Reading Massachusetts.