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THE IMPACT OF INFORMATION ON CONSUMER PREFERENCES

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There are few subjects which have engendered as much controversy in economics as has advertising. An interesting quote on the subject is, "The first purpose of an advertisement is to get itself read [heard]. The second is a secret." [1, p.2]. This is ever so apparent in contrasting the industrial organization literature in economics and the marketing research literature in business. Recently, Albion and Farris have attempted to chronicle and synthesize the various schools of thought [1]. These schools roughly break down into three categories: advertising is information, advertising is persuasion, and advertising reduces marketing costs. Of course advertising may be some of all three and clearly the third depends upon one of the first two being present.

Most of the formal economic modeling centers on the first aspect of advertising: advertising produces information. In large part, this seems to be true because economics as a discipline has never very successfully dealt with taste changes which play the same role as technical change does in the production literature. Yet, it is clear that advertising does convey information about existence, price, and quality. The midweek food advertisements in a local newspaper contain rather obvious examples of all three types of information. Yet, advertisements in the electronic media often do not contain obvious information. The message seems to be that it is refreshing to drink a Pepsi or other soft drink on a hot day. Much of the generic advertising on television also seems to be of the persuasion type. My purpose here is to review some of the conceptual issues of advertising as it relates to consumer information. In so doing, recent thinking sheds some light on how one might think of the persuasion type of advertising in the context of information. For the most part, this is a brief review with little new. It also will indicate something about behavior, but will not give a clear guide regarding functional forms and other details.

Defining Information

Many times one thinks of information as reducing uncertainty or the dispersion of probabilities. This definition leads one astray because information can lead to greater uncertainty [1]. Hirschleifer's definition is compelling: information is anything which alters beliefs [11]. Yet, this definition may be improper unless the alteration occurs in response to an external stimuli and not some subjective evolution. This evolution would put us in the same dilemma as do taste changes.

Given that information is defined qualitatively as an alteration of probabilities, is there some way to quantify information? Since information is so ephemeral, it is little wonder that scalar measures of the quantity of information have not been very useful in economics. Entropy,

$$E = - \int f(u) \ln f(u) \, du \qquad (1)$$

where u is a random variable with probability density (or mass), $f(u)$ and ln denotes logarithm, is a common measure of information. It has several nice properties, one being that more dispersed probabilities lower the entropy measure [26]. The definition in (1) can easily be extended to a change in information, E, as a new signal or message arrives using conditional probabilities. For all of the elegant machinery built up in communication theory using E, it has had little impact on economic modeling — either theoretically or empirically [2]. In order for E to have meaning in economics, we must find a price such that E times this price gives value. Marschak has found some possibility for such a procedure but at present it looks too ad hoc [16]. One would need a clear relationship between the quantity of information, E, and the cost of producing E.

Though the quantity of information is difficult to measure, it is sometimes easy to measure the quantity of an information gathering activity. Suppose we sample sequentially, then the information activity is obtaining the sample which can likely be properly summarized with sufficient statistics. In such case sampling continues past n samples if

$$E\ U(u \mid f^{n+1}(u) - c(n+1)) - E\ U(u \mid f^{n}(u) - cn) \geq 0 \qquad (2)$$

where $\mid f^{i}\ (i=n,\ n+1)$ is the conditional probability density function given i samples and c is the unit cost (assumed constant) of a sample, U is utility, and E denotes expectation. Such models are used extensively in open or closed loop form in the theory of search [17].

Thus, we see that even though the quantity of information might be summarized by the number of samples taken or a vector of sufficient statistics, it is not a clean representation of information. The variable n tells the quantity of information gathering, but it does not necessarily reveal the quantity of information directly. To do so requires some knowledge of how prior beliefs were changed to the posterior distribution.

Though we may have some reservations about defining the quantity of information, it is easy to conceptually talk about its value. When a change in probabilities occurs due to a change in information we can ask for a bid price for the change. If it is positive, then we can say that there is an increase in information. Thus, the value of information is much easier to deal with for economic problems. One must be careful to distinguish correctly the *ex post* (after a message is received) willingness to pay from the *ex ante* (before a message is received) willingness to pay.

The Value of Information

It is tempting to assert that since information can always be disregarded, then the value of information can never be negative. This is akin to modeling the decision maker as having at least the *a priori* expected utility level. It is clear that news can lower welfare so one must carefully consider this notion.

Defining perfect information as the opportunity to observe u before making a decision leads to an average utility level of

$$\int_T [\max_{x \in M} U(x,u)]\, f(u)\, du = E \max_{x \in M} U(x,u) \tag{3}$$

where T is the domain of u and M is the domain of x. Thus, (3) would be the value of utility on average if a perfect forecast of the product's price or quality were available.

The standard *ex ante* model with imperfect information is

$$\max_{x \in M} \int U(x,u)\, f(u)\, du = \max_{x \in M} E\, U(x,u). \tag{4}$$

Let x_u be the solution to (3) and x^* be the solution to (4). Then (3) yields $U(x_u,u) \geq U(x,u)$, or $EU(x_u,u) \geq EU(x,u)$. Letting $x = x^*$, it follows that [13]

$$EU(x_u,u) - EU(x^*,u) \geq 0. \tag{5}$$

Therefore, expected utility with perfect information is no less than expected utility with imperfect information.

Finally, the location of expected utility can be shifted to obtain a measure of willingness to pay. Letting y be income or wealth and entered explicitly into utility, the bid price B or the value of information is

$$EU(x_u,y-B,u) = EU(x^*,y,u). \tag{6}$$

It follows from (5) that B is nonnegative (assuming more is preferred to less). Note that B represents a willingness to pay based upon average *ex post* utility and *ex ante* expected utility. It differs from placing the $-B$ on the right side of (6) or from calculating a $B(u)$ on the left side of (6) and averaging B with the expectation. It is apparent from the above argument that the only time that perfect information has no value is when x does not exist or when $x_u = x^*$. In both cases, we see that the opportunity to perfectly observe u has no value if it makes no difference for behavior. Thus, the greater the flexibility to adjust $[|x_u - x^*|]$, the greater is (5) and greater is B.

The above simple proof highlights another important point. The decision maker's subjective view of $f(u)$ must be correct. That is, the same $f(u)$ was used for both expectations in (5).

The real information issue is that information does not lead to certainty and so called subjective beliefs are changed according to our definition as information changes. If the prior density is $f(u)$ and the posterior density is $g(u)$, then the bid price between the two distributions is

$$\max_x \int_T U(x,y-B,u)\, g(u)\, du = \max_x \int_T U(x,y,u)\, f(u)\, du. \qquad (7)$$

In such case, it is not true that B is nonnegative even when information doesn't cost.

Research has proceeded in two directions. Gould, Hess, and others have asked what happens to the magnitude of the left side of (5) as the spread of the distribution is increased while preserving the mean [7,9]. That is, $f(u)$ is stretched while preserving the mean to arrive at $g(u)$. Gould established that there is no obvious relationship between the value of perfect information and increases in risk. Hess found that increases in risk increase the left side of (5) when U is concave in x and u and when $(\partial^2 U/\partial u^2)(\partial U^2/\partial x^2) \leq \partial^2 U/\partial U\ \partial x$. The other line of research asked when the news was good or bad without explicitly modeling x but formally using Bayesian decision theory in the analysis. This is equivalent to asking the question, "For all decision makers, is it possible to characterize when a message raises (lowers) expected utility without knowledge of U?"

In exploring this issue, suppose that messages are independent of u. Such might be the case for typical stockmarket prophets. For two messages z and w, the difference in expected utilities is

$$\int U(u)\, f(u|z)\, du - \int U(u)\, f(u|w)\, du. \qquad (8)$$

In this case, the conditional distributions are the *a priori* distributions $f(u)$ and $g(u)$ and information has no value. This would be true whether we explicitly modeled x or not because the messages were not information. Thus, neutral news is when $f(z|u)$ is independent of u. Good news is defined as news such that for any nondegenerate prior distribution, the posterior distribution leads to a rise in expected utility. This is recognized as the condition necessary for first degree stochastic dominance of the posterior distribution. Milgrom shows that this occurs when $f(z|u)$ is increasing in u. Using Bayes rule, good news raises the posterior distribution such that the cumulative distribution function shifts right with good news. The better the news the more the shift. In the context of product quality, if the monotonicity property held, one could infer good news based upon purchase behavior. Particular families of distributions have the monotonicity property which in the statistics literature is called a monotone likelihood ratio property.

If the monotone condition does not hold, then one can't deduce unambiguously whether the news is good or bad. With some increased difficulty, these concepts undoubtedly can be extended to the case of second degree dominance which considers risk averse decision makers.

Another question of interest is "can one use informational gathering behavior to infer the value of information?" In several recent papers it is clear that the area under these demand curves, when expected utility is compensated to its original (subsequent) level, is an exact measure of compensating (equivalent) variation as defined by Hicks [10]. Using the ordinary demand curves provides an approximate measure of the welfare change. Since information per se cannot be easily quantified this is as far as we can go.

Information and Consumer Demand

There has been a proliferation of industrial organization literature on information. To understand it all and synthesize it would be a helpful but large undertaking. Rather than review the seminal article of Stigler's [25], a more recent article by Kihlstrom aimed directly at product quality seems more appropriate for discussion [12].[2]

A hedonic type attribute model is used such that each commodity produces one characteristic or attribute. One good (meat) produces protein with certainty with a linear production function with an input/output coefficient of unity. A second good (cereal) produces carbohydrates with an uncertain production function with a multiplicative disturbance. The unknown coefficient of cereal is assumed to be lognormally distributed. The consumer must choose optimally how many samples of cereal to take to a testing lab or otherwise glean information on the quantity of meat and cereal to purchase. Using a constant elasticity of substitution utility function and preposterior analysis, Kihlstrom shows that sampling is an inferior good and that it is not a Giffen good (that is, sampling declines as its cost rises).

Another interesting result is that information demand is highest for commodities for which the expected quality is neither very high nor very low. Further, the quantity of information demanded is a decreasing function of the consumer's confidence in his or her *a priori* expectations. That is, when beliefs are strong with a mean near zero or very large, then cereal demand does not respond to the sample value and hence sampling has no value. Further, consumers will not purchase information about an uncertain product that is either very inexpensive or very high in price relative to other products or when preferences are strongly skewed towards a particular commodity. Some of these results are generalized in a later paper [13]. The Slutsky matrix is negative semidefinite for the informational gathering activities. In other words, compensated demand curves for samples are downward sloping. Many of these results are rather transparent when Silberberg's primal-dual approach is used [24].[3]

A Suggestive Model of Advertising in the Kihlstrom Model

As was apparent above, uncertainty creates many ambiguities in the theory. Here, this is emphasized with an explicit model of consumer behavior in which the consumer is provided, at no cost, information in an advertisement. We sidestep many of the deep psychological issues on the nature of advertising and cognition and merely assert that advertising changes the distribution of perceived quality.

Since advertising is modeled as received at no cost, it is assumed that it pervades our environment so that no conscious effort is required to obtain the information. This implies that there is no need to do a sequential type preposterior analysis. The basic Kihlstrom model is adopted except that advertising must be explicitly entered. The model is

$$max\ EU(F(x_1,A) + H(x_1,A)u, G(x_2)) \tag{9}$$

subject to $p_1x_1 + p_2x_2 - y = 0$ where the p's are prices. Letting r be the Lagrangean multiplier and L be the Lagrangean function, it can be shown that $L_{Ax}[x_A + x_y\ (0\ 0\ x_1\ x_2)]$ is positive semi-definite, where A represents the parameters of the problem excluding income and the subscripts A and x denote derivatives. That is, L_{Ax} has typical element $\{\partial^2 L/\partial A \partial x\}$. For the problem in (9), optimization implies that

$$\begin{bmatrix} T_1x_{1A}+T_2x_{2A} & T_1x_{1R}+T_2x_{2R} & T_1S_{11}+T_2S_{21} & T_1S_{12}+T_2S_{22} \\ T_3x_{1A}+T_4x_{2A} & T_3x_{1R}+T_4x_{2R} & T_3S_{11}+T_4S_{21} & T_3S_{12}+T_4S_{22} \\ -rx_{1A} & -rx_{1R} & -rS_{11} & -rS_{12} \\ -rx_{2A} & -rx_{2R} & -rS_{21} & -rS_{22} \end{bmatrix} \tag{10}$$

is positive semidefinite and positive definite except in generally two dimensions (directions), where the S_{ij} are the usual Slutsky terms, R represents a mean preserving increase in risk, r is the multiplier which is negative, and the T's are the following expressions

$$T_1 = E\{U_1(F_{Ax1} + H_{Ax1}u)\} + E\{U_{11}(F_A + H_Au)(F_{x1} + H_{x1}u)\}$$
$$T_2 = EU_{12}(F_A + H_Au)G_{x2}$$
$$T_3 = EU_1H_{x1}u + EU_{11}(F_{x1} + H_{x1}u)Hu$$
$$T_4 = EU_{12}HuG_{x2}.$$ [4]

where the subscripts on U denote derivatives. Though these results and notations are numerous even for this simple problem, a few points can be readily made. First, using the southeast portion of the matrix in (10), it is apparent that the price Slutsky matrix has the usual properties of symmetry and that compensated demand curves for x_1 and x_2 are downward sloping. Further, maximization implies that the term in the first row and first column of (10) is positive (nonnegative). That is, a weighted average of the impacts of advertising on demands is positive. In the case of additive utilities as in Kihlstrom case (the CES), $U_{12} = 0$, *the* T_2 term vanishes because marginal utilities are independent. When $F=H$, then the ambiguities in signing T_1 largely disappear. The first term is signed as opposite the sign of the term in parenthesis since under risk aversion, EU_1u is signed negative [22]. The second term of T_1 is opposite in sign to F_AF_{x1} [22] under risk aversion (U_{11} negative). If advertising raises the marginal product of x_1, then the first term is positive. If advertising and x_1 have a positive marginal product for a given u, then increased advertising leads to a rise in x_1 demanded. Since firms will not advertise unless demand increases, something like these conditions must be envisioned.

When F is not equal to H, then advertising may decrease the variance of the perceived characteristic but increase the mean [22]. In such case F_A is positive but H_A is negative. This tends to make the second term positive as well.

For the impact of increased risk under additivity, then the sign of the (2,2) position depends on the sign of T_3. It is clearly negative under risk aversion when $F=H$ and an increase (decrease) in risk would imply a decrease (increase) in the consumption of x_1.

The overall conclusion is: How advertising interacts with the perceived transformation of goods to characteristics is vitally important in determining whether increased advertising leads to an increase in demand. The difficulty in answering this question unambiguously even in this simple model, discourages one from pursuing such issues as whether increased advertising leads to a more elastic or inelastic demand function [5].

Noninformative Advertising

In a series of important papers, Nelson distinguished between a "search good" and an "experience good," for example, Nelson [21]. The former is characterized by traits that are readily apparent upon inspection. Price of a good is such a trait. As far as product quality is concerned, advertising is likely to be directly informative because, upon inspection, the truth can be easily verified. Experience goods must be experienced in order to assess quality. Although the good must be consumed to begin to verify its quality, even consuming the good may be a very imperfect indicator of food quality, safety, and nutrition. Nelson argues that since it is in the firm's interest to advertise high quality, ads probably do not convey much direct information. Yet, the consumer must try to identify which goods are high and which goods are low quality.

Nelson drew on recent signaling literature to explain the noninformative phenomenon. He argued that goods with high quality are more likely to have repeat customers, thus they have a higher marginal benefit to signaling the quality to the customers. Thus, firms with high quality products advertise more in order to signal this to customers. In this respect, the story closely resembles the signaling story of the accumulation of education and training. One signals that one is a high quality individual by acquiring more education. In order for the story to work, low quality individuals must have greater difficulty (marginal cost) in obtaining the signal.

The Nelson argument is quite compelling for some advertising. Whether firms with higher quality products find it more beneficial to advertise is an empirical question. In any case, an explanation of so-called uninformative advertising is given which does not rely on persuasion. Note that it is really a misnomer to label such advertising as uninformative. It is merely uninformative regarding specific attributes of the product and thus is said not to contain direct product information.

In a recent paper, Milgrom and Roberts have generalized Nelson's argument to formally model the case where both price and advertising can signal quality [19]. Presumably, a higher price implies a higher quality on average. The general conclusions of their deductive inquiry are: (a) advertising can sustain a signaling equilibrium, but price signaling will typically occur also, (b) the inclusion of price signaling "upsets the intuition that a high quality producer will have a higher marginal benefit from attracting an initial sale and that this would provide the basis for the high quality firm's being willing to advertise more." The reason this occurs is that there is a non-uniqueness in defining the marginal customer. Price may be increased costlessly by a high quality firm until a particular price is obtained (where the marginal benefit of a price is equal for high and low quality firms). Then advertising is used as a signal.

Some Comments on Marketing Literature

Within marketing research literature there are numerous studies regarding cognition, recall, and the overall effectiveness of various forms of advertising and information. There are two areas of this literature that I wish to comment on. The first is that there is some evidence that the same quantity of unfavorable news is weighted more heavily in decisions than favorable news [20]. Mizerski reviews three potential reasons for this possible phenomenon. Unfavorable news carries more surprise. It is less ambiguous and more likely to be correct.[5] The underlying theory is referred to as attribution theory. This theory states that the more an individual attributes a piece of information received from another party to the product's factual performance or actions the more will be the influence of the information on decisions. That is, "subjects perceived more nonstimulus causes (causes other than the entity on which information was being provided) for favorable behavior or information, and thus the possibility of the information having a stimulus cause (originating in the entity) was discounted" [20]. Mizerski refined and extended these arguments and found additional empirical support for this hypothesis.

The second area of the marketing literature of interest is called informational overload. That is, as the quantity of information increases, might consumer choices be in error more frequently so that the reliability of responding to the choices falls with increased information [15]? This might imply that reliable behavior dictates ignoring information or processing information very selectively. Recently, Heiner has stressed that all of nature seems to have the innate ability to restrict response to information in order to enhance reliability [8].

Generic Advertising and The Value of Information

As Gallo shows, advertising expenditures for food vary in purpose [6]. There are heavily advertised brand name foods and there are generic advertising, promotions, coupons, and other devices designed to increase demand. Each of these requires different modeling to assess properly. Some of these are likely profitable just based upon price discrimination because consumers have different amounts of information. That is, first time users of a product have less information and a lower reservation price for the product. Porter would credit this structure to advertising, labeling it "pull" promotion. The unique feature of food advertising is the large quantity of generic advertising. The free rider problem in a market characterized by homogeneity of products is an obvious reason why this exists from firms' points of view. The question is, do consumers respond sufficiently to the advertising and why? From the discussion above, it is clear that generic advertising provides information such as the nutritional content for eggs and potatoes. It also tells the cost per unit of nutritional characteristics and provides other price information which also reduces the search costs to the consumer. Yet the preponderance of electronic media advertising conveys little information except that the product or firm exists. Nelson, based upon the notion of "experience goods", explains these noninformative advertisements. Though the notion of signaling is probably very important in general, it is difficult to assess how it fits in with generic advertising. One would have to say that commodities that are heavily advertised are of a higher perceived quality. Recently, an argument has been advanced that market share is a signal of quality or desirability but the mechanism that makes it an effective signal was not discussed [3].

The attributional theory suggests that unfavorable messages might be given disproportionate weight. This may explain why advertisement for milk, eggs, and red meats (and others) is so important to producers since these foods have had considerable negative messages in recent years. Thus, Milgrom's treatment of good and bad news would need to incorporate the fact that $f(z \quad u)$ is large for low values of the message z where f is the conditional density.

To conclude, the direct informational content of much advertising is low. Whether there is direct or indirect informational content, the model in (9) is a reasonable starting place to begin modeling consumer choice with advertising reducing uncertainty. Yet, it seems apparent that much of advertising's impact is more subtle than the provision of information as modeled above. It could be persuasion, but probably economists should be reading more literature on cognition and recall. Perhaps an advertisement portraying the refreshment of a cold glass of milk on a hot day serves to reduce the cost of recall from the mind of such utility. In this case, search costs are entirely internal. Further, perhaps consumers' processing of information is extremely selective so that advertisements, though subtle in many cases, do convey the relevant information so that overload (if it exists) does not occur.

FOOTNOTES

[1] A weather forecast may imply a 50-50 chance of rain whereas the *a priori* beliefs were predominantly no rain.
[2] Stigler's article dealt mostly with nonsequential search for the lowest price [24]. It established that the marginal benefit from search is declining as the sample (search) increases. Since generic advertising fits most closely into the product quality framework, it is considered here.
[3] In an unpublished paper with Jean Paul Chavas, we develop conditions under which a generalized Slutsky equation has the usual slope properties [4].
[4] The reader is referred to Pope and Kramer for information on the technique of the mean preserving spread with this production function and to Silberberg for a simpler way to derive these comparative static results than using Cramer's rule [21,23].
[5] Perhaps this is why we believe a used car salesman when he or she points to a problem with a car. That is, perhaps we feel that a person is more motivated to say positive things about a product.

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