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A THEORY ON INFORMATION AND ITS APPLICATION
TO THE EFFECT OF LABELING ON FOOD PRODUCTS

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A THEORY ON INFORMATION AND ITS APPLICATION TO THE EFFECT OF LABELING ON FOOD PRODUCTS*

by

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Richard J. Sexton

I. Introduction

It is generally understood that when a consumer purchases a product he/she has actually chosen the product for certain attributes or characteristics contained in the product. For instance the attributes contained in a typical food product might be taste, energy, nutrients or convenience of preparation. This approach was first introduced by Lancaster (1966). A problem arises in this regard if the consumer does not have complete knowledge of or access to data regarding all the attributes contained in any product. When such a situation exists it leads to the likelihood that the consumer's expenditure decisions may not be optimal and that budget misallocations will occur.

In particular the concern over the quality of Americans' diet and consumers' lack of knowledge about food products led in 1969 to the White House Conference on Food Nutrition and Health (Final Report, 1970). One result of this Conference was a call for some standardized system to provide nutritional and other information to consumers. As a result rules were promulgated by the Food and Drug Administration (FDA) in 1972 and approved in 1973 (U.S. Department of Health, Education and Welfare, (USHEW), 1973[1]) requiring the now familiar standardized nutritional label for all packaged food products which either are nutritionally fortified or which make nutritional claims. In addition the regulation provides that any nutritional data voluntarily provided to be in the FDA format. Beloin (1973) provides a summary and explanation of the regulations.

Since the first nutritional labels began appearing in 1973 there has been a good deal of study concerning the benefits and effectiveness of the existing regulations and the possibility of their expansion or alteration. Statutory authority in the area of food labeling is split among three federal agencies. The United States Department of Agriculture (USDA) has jurisdiction over meat and poultry products with the FDA controlling all other foods. The Federal Trade Commission (FTC) is involved in food labeling through its responsibility for regulation of food advertising. An FTC proposal in 1974 (presently unadopted) would have mandated that television commercials for foods required to have nutritional labeling on packaging contain nutritional and caloric information or make a statement as to the lack of such nutritional value (Bettman, 1975).

The FDA on the other hand seems to be taking a wait and see attitude regarding the effectiveness of present regulations before proposing extensions or alterations. Among the possibilities currently being considered by FDA are alterations in the format in which the data is presented (USHEW, 1978_1). Suggested changes include elimination of numbers from the label and replacing them with graphs or wedge charts or adjectives such as good, fair or poor. Also FDA is considering expansion of regulations to require disclosure of data about certain specific substances in food which consumers may want to avoid for various reasons. In this regard FDA intends to propose that sodium and potassium content be declared on all nutritional labels. In an attempt to ascertain the effectiveness of existing regulations and to determine consumers perceptions of possible changes FDA, FTC and USDA jointly held public hearings on the issue of food labeling at five locations in the U.S. from August 22 to October 29, 1978 (USHEW, 1978_1, 1978_2).

Studies and research on the effects of label disclosures have not been able to discern any particular tangible benefits accruing to consumers from the regulations. Consequently advocates of label disclosure have been forced to rely on criteria such as the consumer's "right to know" to justify their call for disclosure regulations (Daly, 1976; USHEW, 1978_2).

An interesting dichotomy seems to have been uncovered in studies concerning consumers' use of nutritional data. It appears when asked, a large percentage of consumers will say they want nutritional data, they will use such data and they would be willing to pay something extra to have such data. However, studies pertaining to actual usage of nutritional data tend to show that consumers often don't understand the data in the format presented and seldom make use of it.

In particular a survey by Lenahan, et al.,(1972) indicated nearly 100% favored nutritional labeling, 60% would use such data and 44% would be willing to pay more on their food bill for it. A similar national survey of 1500 persons by FDA (USHEW, 1973_2) produced similar results. Seventy-five percent said they would use nutritional labeling and almost half were willing to pay 50¢ more per week on their food bill to have such labeling. Ironically a repeat survey by FDA (USHEW, 1975) after the requirements had been in effect for awhile indicated a somewhat less favorable outlook towards labeling. Fifty-eight percent of respondents reported to have noticed nutritional labeling on food products and from this group 57% had used the data (this group comprises 33% of the entire sample). Only 40% were now willing to pay an extra 50¢ a week for the data.

A survey of New York state households by Daly (1976) indicated 91% were concerned about nutrition and 58% were willing to pay something extra on their food bill for it. A national survey of women conducted by the Gallup organization for Redbook (1976) reported 91% were concerned about nutrition, 76% were interested in having more information about nutrition, 66% had read nutritional labels "during the last several months" and 49% were willing to pay an extra 3¢ per food item to have nutritional data be placed on all foods. A study by Lichtenstein (1974) reported 71% would use the label data and 54% were willing to pay something extra on their grocery bill to have it. Another national survey by the Economic Research Service (ERS) in the U.S. Department of Agriculture (USDA, 1977) reported 54% found nutritional data useful or extremely useful. This figure increased to 63% in a followup phase of the survey conducted about a year after the first phase.

The results of these and other surveys in the area are quite similar. They indicate, as mentioned earlier, that a large majority of consumers want nutritional data and have a desire to use the data. Generally about half indicate some willingness to pay extra to obtain the data. The problem is that studies report that actual usage of the data by consumers is minimal, and consumers often have difficulty understanding the data in its present format.

Lenahan, et al.(1972) reported that only 15% of respondents understood the labels and only 10% used them. As noted earlier FDA (USHEW, 1975) reported one-third of consumers had used the data. The Redbook survey (1976) reported 58% found information about nutrition confusing. Similar results were reported by Jacoby, et al (1977). They found that consumers did not utilize much of the available data especially when brand names were available. They also found that acquisition decreased as the number of items shopped for increased. During long shopping trips data acquisition was estimated to be less than 10%.

The authors concluded that the majority of consumers neither use nor comprehend nutritional data in making food purchase decisions.

In a test of the FTC proposal to require presentation of nutritional data on television commercials Scammon (1977) compared two peanut butter spreads (Skippy and Koogle), and nutritional data were fabricated to make Koogle appear more nutritious than Skippy. The data were presented in the proposed FTC format. The results showed that in spite of advertising to the contrary a large majority of respondents thought Skippy was more nutritious. In fact those presented with the fabricated data were more apt to conclude that than the control group.

When respondents in the second FDA survey (USHEW, 1975) were asked if they understood label components, most claimed they did. For instance some reported levels of understanding are as follows: calorie 82%, RDA 64%, protein (grams) 62%, fat 58%, cholesterol content 51% and sodium content 36%. However, direct questioning regarding nutritional knowledge often did not bear out the claims.

Particularly distressing to supporters of nutritional disclosure is the fact that low income groups, those with lesser education and the elderly (those most in need of dietary improvement) are least likely to understand, acquire and use nutritional data. Daly (1976) reported that difficulty in understanding or utilizing data was much more acute among the poor, aged and uneducated. Chi square tests to measure differences in response to questions concerning ability to process and use information were significant at .05 or less for groupings based on age, income and education. The FDA (USHEW, 1975) reported only 25% of those over 50 had used nutritional labels, and use was only 24% for those with low socioeconomic status. These groups also expressed much less willingness to pay extra for such data. The ERS report (USDA, 1977) indicates similar findings in this area also. Conversely the Redbook survey (1976) indicated only minor variations in response based upon age.

Some evidence does seem to indicate that consumers are becoming more aware of nutrition and labeling in recent years. Better Homes and Gardens (1978) found 78.5% within a panel of its readers had read label information in the last ten days. Redbook (1976) reported 66% had read labels during the past several months.

Summaries of the literature on labeling have been provided by General Mills (1978) and Babcock, et al.(1975). Costs to industry for providing labeling have been reported by Albrecht (1978), General Foods (1975) and the Wall Street Journal (1973). Rusoff (1978) summarizes the industry viewpoint on labeling. Summaries of the Government's outlook towards labeling have been provided by FDA (USHEW, 1978_2) and Forbes (1978).

The understanding of factors in consumer information processing is important in determining why consumers often fail to utilize the information resources at their disposal. The well supported principle of concreteness says that consumers tend only to use information that is explicitly displayed in the stimulus and will use it only in the form in which it is displayed. Information that has to be stored in memory, infered from stimulus or transformed tends to be ignored. From this Bettman and Kakkar (1977) have concluded that policy to make data available to consumers is not sufficient. The data must be presented in a form which is readily processable.

A study by Stanley (1977) tends to verify this proposition. In the study consumers were presented with nutritional data on cereals and then immediately after were asked to rank the cereals on perception of nutritional content and preference. The result was a correlation = .678 between the nutritional ranking of the cereals and consumer choice. An R^2 = .945 was obtained for amount of variance in preference explained by nutritional perception. Quite obviously this was a case where data was presented in an easily processable format and where it didn't have to be stored in memory.

Bettman and Kakkar (1977) also note that consumers acquire and process information through either of two basic strategies. Choice may be made by processing brands of a product whereby one brand at a time is chosen and information is gathered on several attributes, then another brand is examined, and so on. The other strategy is processing by attribute where a particular product attribute is examined for several brands, and then another attribute is examined, and so on. Studies have shown that consumers will process data in the fashion easiest given the display. Since most displays emphasize brands, processing by that strategy is encouraged and processing of attributes such as nutritional value is naturally decreased.

In this regard Assam and Bucklin (1973) performed a latin squares analysis of variance experiment to test consumers' preference of different label types. They found that manufacturer's promotional statements on the label were just as effective at influencing consumer's purchasing decisions as positive nutritional data. Similar conclusions were reached by Berning and Jacoby (1974) who found that manufacturer determined data including price, advertising and packaging are key factors in generating interest and awareness. Other factors become important only at later stages. One could conclude from this that tailoring displays to emphasize nutritional attributes would encourage processing by that attribute.

In a summary article of the work on consumer use of information aids Monroe Friedman (1977) concluded that overload of information and lack of public understanding of the data provided were the basic problems causing consumer failure to effectively utilize data at their disposal.

II. An Economic Theory on the Effect of Labeling on Food Products

A. Determination of losses from imperfect information

The situation reviewed in the preceding pages is basically a problem dealing with the nature of consumers' demand for and usage of information, i.e., why do consumers on the surface want more data on food labels and then when it is provided apparently fail to make use of it. To explain this and other problems pertaining to product information acquisition, this portion of the paper will develop a theoretical framework within which the benefits and costs of providing information to consumers can be analyzed. Due to the great variety of products on the market, attempts to develop a theory sufficiently general to encompass all or most products would be a difficult and questionable undertaking. I will restrict the framework of this analysis to food products and potential information disclosures concerning them.

Before proceeding it is necessary to distinguish between information and data. Information can be defined as data which increases the knowledge of the recipient. Data is therefore potential information. Before it becomes information it must be processed by the recipient. The concern of this paper is with data and information about particular food products. The data in this case is produced either voluntarily or through regulation by the food processor. But information is produced by the consumer through a household production function of the type developed by Becker (1973) with the inputs being new data, prior information stored in memory and time. The mere existence of data on a food label will do nothing unless the consumer processes it into information. Since the type of data being dealt with here is either mandated by regulation, or if voluntarily provided, subject to regulatory guidelines; it is assumed for purposes of this paper that all the data provided is accurate and not misleading.

Start with a consumer's demand curve for some food product which can be called product 'A'. This demand curve at any time is largely determined by the consumer's perception of the attributes contained by the product (Lancaster, 1966). This evaluation is made based upon the knowledge and information available to the consumer at the time. Some of the attributes of the product are readily discernable simply by trying the product, for instance the way a product tastes can be quite accurately determined in this fashion. Knowledge about other attributes such as nutritional content cannot be easily determined in this manner. Therefore in a state of imperfect knowledge and incomplete information the consumer's existing demand curve for 'A' may be different from what it would be in a state of perfect information.

Let D_1 be the consumer's initial demand curve for 'A' based upon his/her subjective evaluation of the attributes of 'A' in period t. Now define D_T as the consumer's true demand curve for 'A' based upon perfect information. If $D_1 \neq D_T$, the result will be a misallocation of consumer expenditures with corresponding changes in consumer's surplus and losses in welfare.

To formulate this loss assume in the absence of perfect information that the following three possibilities exist with some probability of occurance attached to each:

(1) The consumer has overevaluated the true quantity and nature of attributes contained in the product and $D_1 > D_{T(1)}$ where $D_{T(1)}$ is the demand curve which would occur with perfect information if this situation holds.

(2) The consumer has underevaluated the true quantity and nature of attributes contained in the product and $D_1 < D_{T(2)}$, where $D_{T(2)}$ is the demand curve which would occur with perfect information if this situation occurs.

(3) The consumer has correctly evaluated the attributes of the product and the current demand curve, in this case D_1, is equal to the demand curve, D_T, which would occur with perfect information.

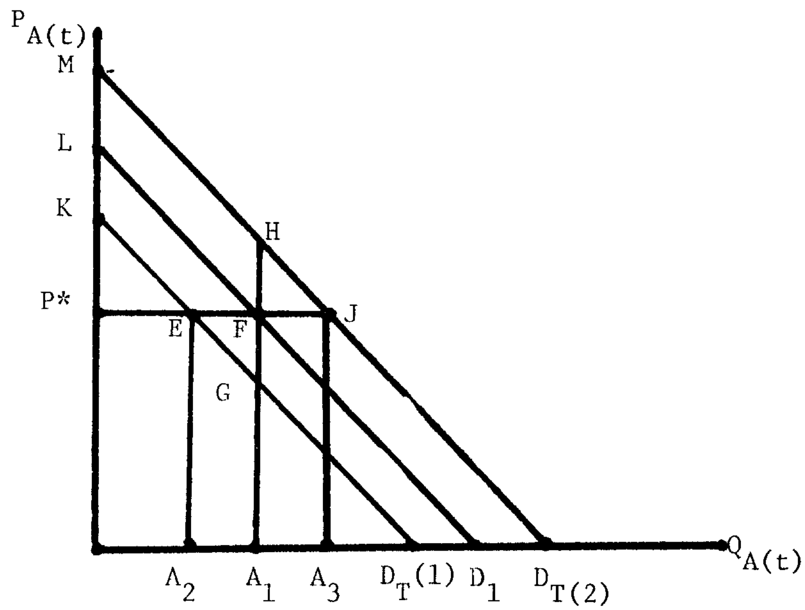
Only one of these situations can actually exist at any time so the probabilities of their occurrence sum to one. Letting X_1, X_2, X_3 stand respectively for the probabilities of (1), (2) and (3) occurring it can be said that

$$X_1 + X_2 + X_3 = 1.$$

Note that only one of $D_{T(1)}$, $D_{T(2)}$ or $D_1 = D_T$ <u>actually exist</u> at any time as the demand curve which would be attained with perfect information.

The consumer incurs a loss in terms of welfare if either situation (1) or (2) occur. There is, of course, no loss if (3) occurs.

Figure I



Using the above figure and assuming a constant market price for 'A', P*, the loss if (1) or (2) occurs can be formulated (Peltzman, 1973). If (1) occurs it becomes clear that the consumer has purchased too much of 'A'. He/she has purchased A_1 units in period t but actually should have purchased only A_2 units. For the additional units, A_2 A_1, beyond A_2 which the consumer purchased he/she paid an amount equal to A_2 EF A_1, but the actual value of these units to him/her as now revealed by $D_T(1)$ is only A_2EGA_1. Therefore the consumer has incurred a welfare loss in period t on these units of A_2EFA_1 - A_2EGA_1 = GEF. If (2) occurs then the consumer has purchased too little of 'A' and she/he should have purchased A_3 rather than A_1 units.
The consumer's surplus in period t would have been P*MJ had he/she purchased A_3 units, but since only A_1 units were purchased the surplus on the remaining units, A_1A_3, is lost. This surplus loss is represented by the area FHJ.

Multiplying the loss to the consumer if (1) or (2) occur by the probability of their occurrence (X_i) enables one to formulate an equation for expected loss (EL) to the consumer in period t from imperfect information:

$$EL_{(t)} = X_1\ [1/2(EF)(FG)] + X_2\ [1/2(HF)(FJ)]. \tag{E1}$$

Letting the respective demand curves be written as follows:

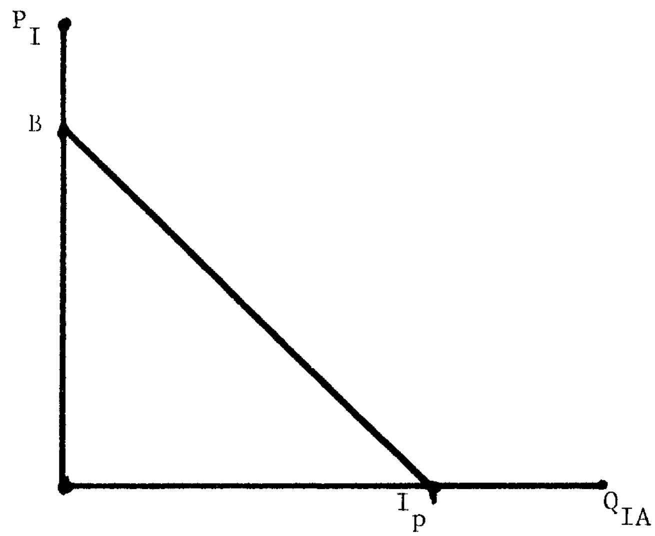
$$D_1:\ Q_A = f^0(P)$$
$$D_{T(1)}:\ Q_A = f^1(P)$$
$$D_{T(2)}:\ Q_A = f^2(P)$$

the expected loss can be formulated as follows:

$$EL_{(t)} = X_1\ [\int_0^{A_2} f^1(P)\ dp + ((A_1-A_2)\ P^*) - \int_0^{A_1} f^1(P)\ dp] + X_2\ [\int_0^{A_3} f^2(P)\ dp - \int_0^{A_1} f^2(P)\ dp - ((A_3-A_1)\ P^*)]. \tag{E2}$$

Equation 2 shows that the consumer can expect to incur some dollar loss from misallocation of expenditures on good 'A'. The consumer, therefore, has incentives to obtain information which would reduce this EL, and she/he should be willing to pay for data (potential information) an amount equal to the reduction in EL which would be obtained with more information. A consumer demand curve for additional information about product 'A' can thus be formulated based upon this willingness to pay. Let B_{Ip} (Figure II) be the consumer's demand curve for additional information (I) about 'A'. The point where the demand curve intersects the horizontal axis, I_p, is significant because it corresponds to the level of information needed to

Figure II



obtain perfect information about 'A'. To see this, note that any new information the consumer obtains about 'A' can be expected to reduce EL from misallocation. The larger the level of information obtained the smaller becomes EL and the less becomes the willingness to pay for additional information. It follows directly that the consumer's willingness to pay for the last bit of data that will give "perfect" information goes to zero since the loss from misallocation has also gone towards zero. At this point $\partial Q_A/\partial I_A = 0$. Further information will not affect the level of 'A' purchased.

Now formulate the demand curve for information about 'A' as follows:

$$P_I = f(Q_{IA})$$ */

where P_I = the price of information or willingness to pay for information

Q_{IA} = quantity of information about 'A'.

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*/ This formulation is chosen because quantity of information is usually provided exogenously by regulation. The quantity provided thus determines willingness to pay.

The demand curve BI_p is based on the consumer's willingness to pay for information to reduce EL. In particular since EL = 0 with perfect information it must be true that

$$EL_{(t)} = \int_0^{I_p} f(Q_{IA})\, dQ_{IA}. \tag{E3}$$

The expected loss is equal to the area under the information demand curve. This means that the demand for information will be greater for those products which have a greater EL.

Given the information demand curve, BI_p, assume now that through government regulation or voluntary producer initiative some quantity of nutritional data is provided exogenously on the label of 'A'.

Assume the consumer obtains OI_1 in additional potentially useful information from the data. The consumer's willingness to pay for this data is

$$\int_0^{I_1} f(Q_{IA})\, dQ_{IA}. \tag{E4}$$

In period t the consumer purchases some finite quantity, A_1, of 'A', where $A_1 \geq 0$. E4 gives his/her willingness to pay for the OI_1 in potential information which now appears on each package of 'A'. The consumer would then be willing to pay this amount extra for a package of 'A' containing the potential information. But he/she would be willing to pay this extra amount only one time since repeated encounters with the data would provide no new potential information. If the consumer perceives the label disclosure on the A_ith purchase of 'A' in period t, he/she would then be willing to pay a price for this unit equal to

$$\int_{A_{i-1}}^{A_i} f^0(P)\, dp + \int_0^{I_1} f(Q_{IA})\, dQ_{IA}.$$

Graphically, this could be interpreted as a break in the consumer's demand curve at whatever unit he/she encounters the new data. It would be expected that consumers of 'A' would encounter the new data at various points along their individual demand curves during the period t. Also since consumers may have previously acquired and processed elements of the new label data through other means, the amount of potential new information will vary for each consumer in that data with which a consumer is already familiar cannot be expected to further decrease his/her EL. Further note that willingness to pay for each unit of potential information is unique to each consumer since it is determined by EL which will certainly vary from consumer to consumer.

Considering the total market demand, obtained by summing each individual demand, it would follow that this curve would temporarily shift out during any market period in which a labeling scheme had been instituted. This shift would be a reflection of consumers' additional willingness to pay for a package containing the new data. As a practical matter this should be a very transitory situation which will exist only in the period of initial exposure to the new data and prior to evaluation of it. Once consumers evaluate the data a new market demand curve will exist as a consequence of changes due to evaluation in individual consumer's demand.

The consumer's willingness to pay for OI_1 in potential information is represented by E4. The demand for information is determined by EL, and the consumer is willing to pay a price for this data equal to the reduction in EL that will be generated by the data. By subtracting E4 from the formulation for EL, E2, one obtains a new EL, EL', which will exist after evaluation of the new information. Therefore,

$$E2 - E4 = EL'$$

To determine how information reduces EL assume that upon processing the data the consumer decides one of three things:

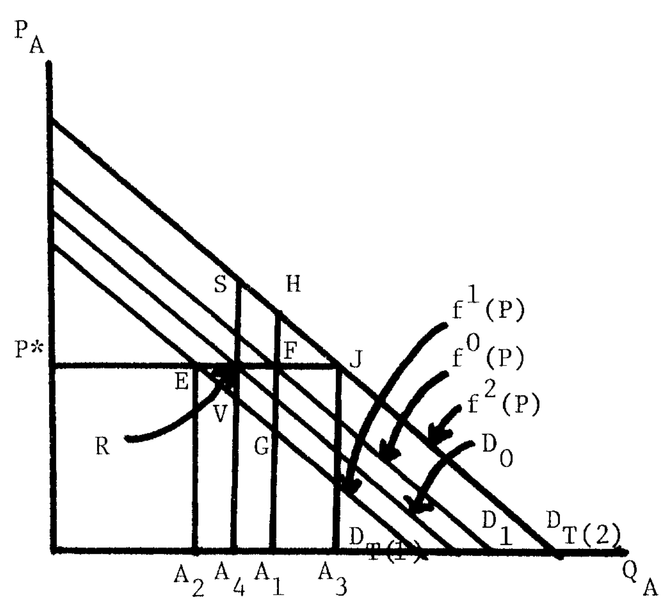
(1) He/she has been overevaluating the product and $D_1 > D_T$.

(2) He/she has been underevaluating the product and $D_1 < D_T$.

(3) He/she has been correctly evaluating the product and $D_1 = D_T$.

Suppose the consumer decides $D_1 > D_T$, a new demand curve, call it D_0, is formed where $D_0 < D_1$. As long as $OI_1 < OI_p$ the consumer still has incomplete information. This missing information, $OI_p - OI_1$, if obtained could reveal to the consumer that he/she is still overevaluating the product and $D_0 > D_T$, or that he/she is now underevaluating the product and $D_0 < D_T$ or that he/she is correctly evaluating the product and $D_0 = D_T$. If the consumer decides $D_1 > D_T$, he/she will reduce purchases in the present period to some level A_4 on Figure III where $A_2 \leq A_4 < A_1$ (A_2 could be 0 if $D_{T(1)}$ was such that the consumer would not purchase any 'A' at P*).

Figure III



It has been shown that the consumer may still be overevaluating or underevaluating the product after processing OI_1 in information if $OI_1 < OI_p$. As such the consumer will incur losses if either circumstance occurs. The immediate concern is with the change in the area of potential loss due to the reevaluation. By referring to Figure III it can be shown that since the consumer is now operating on D_0 and purchasing less 'A' than before, the loss from overevaluation (the loss if $D_{T(1)}$ is the perfect information demand curve) is less than before. This loss is now expressed by the area REV. However, the loss if $D_{T(2)}$ is the perfect information demand curve, the loss from further underevaluation, expressed by the area RSJ, becomes larger. By letting L stand for the total area of loss the change in the total area of loss can be expressed as follows:

$$\text{(E5)} \qquad \Delta L = \int_0^{A_1} f^2(P)\,dP + \int_0^{A_1} f^1(P)\,dP - [2P^* (A_1 - A_4) + \int_0^{A_4} f^1(P)\,dP + \int_0^{A_4} f^2(P)\,dP].$$

As a result of reevaluation there will be some increase in the area of loss in the event of underevaluation (RSHF from Figure III and some decrease in the area of loss in the event of overevaluation (VRFG from Figure III). These changes tend to offset each other. But depending upon the positioning of the particular demand curves the offset is not likely to be complete, and there may be some increase or decrease in the total area of loss. Therefore, the sign of $\partial L/\partial I$ is uncertain.

It should be noted that it is consistent within the present analysis that situation (3) on page 2 (that $D_1 = D_T$) could still hold true. If this were the case the consumer would now be underevaluating the product due to the added information since $D_0 < D_1$. The loss is obtained in a straight forward manner by setting $D_1 = D_{T(2)}$, which is, of course, consistent with the analysis. It can be seen that E5 still holds true in this circumstance.

It has been shown that the change in the total area of loss from re-evaluation due to new information is uncertain. However, it has also been shown that if information is to be demanded and utilized by consumers, it must be true that $\partial EL/\partial I < 0$, that is, information must reduce the expected loss. According to the development above, increased information does not necessarily reduce the area of loss. It must be, then, that it reduces the probability of these losses occurring. Recall from page 10 that X_3 is the probability that the consumer's current demand curve is equal to D_T. D_0 is now the current demand curve, and D_0 is based upon more information than D_1 was. It must be true then that the probability that D_0 is correct is greater than the probability that existed for D_1 being correct before the additional information was obtained. In other words X_3 has increased due to added information. Since $X_1 + X_2 + X_3 = 1$, it must be that X_1 and/or X_2 have decreased, and therefore that EL has decreased. X_3 can be expressed as follows:

$$X_3 = f(I)$$

and

$$\partial X_3/\partial I > 0$$

where I is the quantity of information obtained about the product.

These results imply that additional information need not result in better purchasing decisions by consumers. In fact it could result in worse decisions. This type of phenomenon has been observed by Jacoby (1977). But since EL has decreased one would expect on average better decisions to follow from increased information.

If upon evaluating the information the consumer decides (2) or (3) from page 16, the same basic results would follow. If she/he decides (2) (that he/she has been underevaluating the product) it will lead to an increase in demand to some $D_0 > D_1$. And if the consumer decides (3), $D_1 = D_T$, there will be no change in demand for the product since he/she still believes D_1 is correct, and since this opinion is now based upon more information the probability is greater now that he/she is right. EL will therefore decrease.

B. Determination of an optimum amount of information provision

1. The costs of information

There are two types of costs involved in information provision. Producers incur a cost in providing the data on the label and consumers incur a cost in processing the data into useful information. I assume there is a one to one potential conversion ratio between data and information, that is, OI_1 in data can through processing be converted into OI_1 in information by the consumer. Remember that since data is defined as potential information the amount of data that exists on any label is subjective and unique to each consumer. The cost to producers for providing data apparently includes some fixed component plus some variable component which is a function of output. General Foods (1975), the Wall Street Journal (1973) and Albrecht (1978) discuss the costs incurred by industry in labeling. The fixed component of cost arises due to expenses incurred in initially obtaining the data and in preparing the label. The variable component occurs due to the need for inspections and monitoring the production process to ensure no deviations from the label specifications. Also it is often argued that per unit production costs are higher due to input rigidity imposed by labeling. In other words manufacturers are unable to alter their ingredient mix in response to price signals if doing so would change the label specifications. As such the cost to producers for providing label data for any food product can be written as:

$$C_p = \alpha + \beta Q_A \qquad \text{(cost for product 'A')}$$

where C_p = the cost to producers for providing label data

α = fixed cost of providing label data

β = per unit cost of providing label data.

The cost to consumers is an implicit cost of time. The more data a consumer wishes to process into information the greater will be the cost in time. The cost to consumers for processing data into information can be written as follows:

$$C_c = \gamma T$$

where C_c = the cost to consumers for processing information

γ = a measure of the opportunity cost of time

T = time required to process data into information.

T can be formulated as follows:

$$T = \lambda Q_I$$

where λ = time required to process a unit of information

Q_I = quantity of information processed.

Lambda (λ) can be interpreted as a function of education and prior nutritional knowledge. The higher one's level of education the more quickly and easily information can be processed and the lower will be λ. Lambda is also a function of the degree of clarity and conciseness with which the data is presented. The clearer and more potentially understandable the data is, the lower will be λ. Over information or information congestion can be interpreted as increasing λ. By substituting for T one can obtain

$$C_c = \gamma(\lambda Q_I).$$

2. The benefits of information

The benefit to consumers from processing information is the reduction in expected loss (EL) from expenditure misallocation. The more information a consumer processes the less will be EL. Since EL determines the demand for information, $P_I = f(Q_{IA})$, the demand for further information decreases. The change in the demand for information with respect to quantity of information obtained measures the reduction in EL from obtaining information.*/ Therefore we have

$$\text{(E6)} \qquad \frac{\partial[\int f(Q_{IA})\, dQ_{IA}]}{\partial Q_{IA}} < 0$$

The value attained by E6 measures the marginal benefit to the consumer for processing information considering the present time period t only. Since the value in E6 is negative the absolute value of the expression is taken

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*/ Information (I) does not appear as an argument in equation E2, also $D_{T(1)}$ and $D_{T(2)}$ are not observable. So although it would be desirable to express MB directly in terms of the change in E2 it is not possible to do so. Therefore it must be expressed in terms of E3 as is done in E6, E6'.

to obtain the marginal benefit in period t, MBt, to the i^{th} consumer from processing information about 'A' in that period.

(E6') $$MBt_i = |\partial(\int f(Q_{IA})\ dQ_{IA})/\partial Q_{IA}|$$

Assuming these benefits are obtained independently by consumers, the total benefit in period t to consumers is obtained by the summation of the individual MBt_i over all consumers of the product.

(E7) $$\text{Total}\ \ MBt = \sum_{i=1}^{N} MBt_i$$

where N is the total number of consumers of the product.

Since it has been shown that willingness to pay for specific types of product data measures expected reduction in EL from that data, an empirical specification of the marginal benefit expression is obtainable by asking consumers how much they would be willing to pay for some additional specific information disclosure. Responses would serve as a proxy for the expected reduction in EL or as the marginal benefit of obtaining the information.

3. Determination of information demand and provision

The benefits to producers from supplying label data depend upon how consumers evaluate the information provided. If, upon processing the label data, consumers decide they have been overevaluating the product, they will reduce their demand for the product and the producer will incur sales losses as well as higher costs due to labeling. The producer will derive some positive benefit from providing label data only if evaluation of the data leads consumers to increase demand for the product. One would expect, therefore, that producers would not voluntarily provide additional label data on food products unless they perceived that evaluation of the data by consumers would lead to an increased demand for the product thus enabling them to charge a higher price or sell a larger quantity. It could also be noted that studies by Daly (1976) and the FDA (1975) have indicated certain indirect effects on consumer behavior from label disclosure. These effects, such as increased consumer confidence, could alter the demand curve for affected products.

The optimum level of information for consumers to process on any product occurs where the marginal benefit of processing (the reduction in EL) is equal to the marginal cost of processing. It has been shown that the marginal benefit curve decreases as additional information is obtained. The marginal cost function as formulated is constant. Considering the present time period t only, the optimum level of information to process on product A from the i^{th} consumer's viewpoint occurs where

(E8) $$MBt_i = \partial C_{c_i} / \partial Q_{IA} = \gamma\lambda = MC_i$$

where MC_i is the marginal cost of processing for the i^{th} consumer and which can be interpreted through $\gamma\lambda$ as being equivalent to the wage rate multiplied by the unit processing time.

Since it is likely that any reductions in loss from information processing would be permanent, it becomes necessary to measure these benefits into future time periods by employing present value considerations to obtain a more accurate representation of the true benefits of processing information. This can be expressed as follows:

(E9) $$PVMB_i = \sum_{j=t}^{M} \frac{MB_j}{(1+r)^j}$$

where $PVMB_i$ = the discounted benefit stream over the life of the i^{th} consumer.

j = time periods t, 2, 3 ...., M

M = remaining life span of the consumer from period t

r = an appropriate discount rate.

The total discounted benefit to all consumers of the product, total PVMB, then becomes

(E9') $$\text{Total PVMB} = \sum_{i=1}^{N} PVMB_i \ .$$

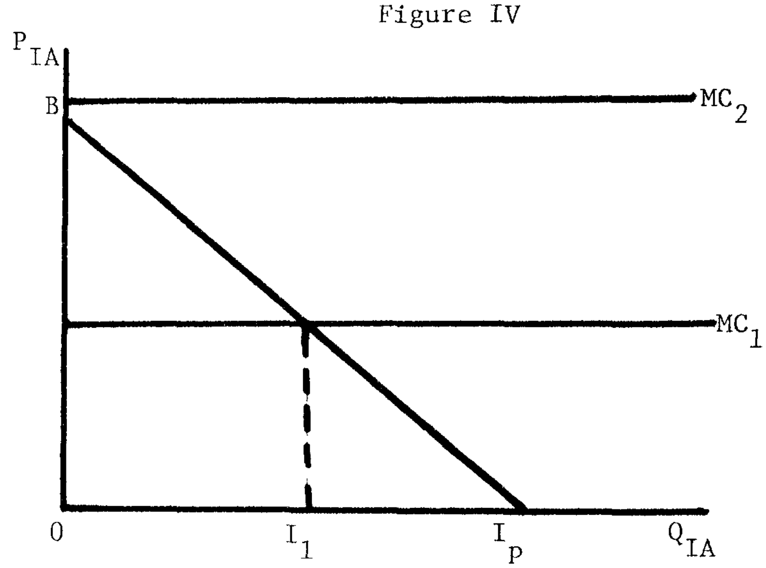
This derivation is analogous to that indicated by Nelson (1971) in his discussion of information search.

C. Analysis of consumer's response to nutrition information

A brief summary of the theoretical framework is in order. It was shown that in the absence of perfect information about a product the consumer incurs some expected dollar loss (EL) from expenditure misallocation. It was then demonstrated how this EL leads to a demand for information by consumers who would rationally be willing to pay for information an amount equal to the reduction in EL that would be generated. Finally it was shown that both producers and consumers incur costs in providing data and information respectively. These costs place limitations on the amount of data voluntarily provided and the amount of information processed.

By appealing to the model it is possible to explain much of the material outlined earlier in the review section of this paper which indicated a high desire by consumers for information but little actual processing or usage of such information. In terms of the model the high desire for nutritional and other information is an expression of the demand curve for information, BI_p. The low actual usage of the data provided is explained when one considers the costs consumers incur in processing the data into information. Another research result outlined earlier, that certain segments of the population (those with low incomes, poor education and the elderly) report a lower than average usage of information, can also be explained in terms of the model. It would be expected that on average members of these groups would incur much higher costs of processing information in terms of λ (time required to process) than other consumers, although this may be offset somewhat by a lower γ (opportunity cost of time). In extreme cases λ would be very large for those who were not literate in English, visually handicapped or unfamiliar with nutrition and nutritional jargon. Figure IV below illustrates this situation. A consumer with a marginal cost of processing information of MC_2 would not process any information if BI_p was his/her information demand curve. If the costs were lower, say MC_1, the consumer would process and use some positive amount, OI_1, of information.

Figure IV



In terms of policy any programs designed to increase consumers' nutritional literacy or to present the label data in a more easily processible format will lead to consumers processing more information which will reduce EL, a socially desirable result. A preliminary summary on the joint hearings conducted by FDA, FTC and USDA reports senior citizens, "individuals of low comprehension", non-English speaking people and children were very much in favor of proposals to present the label data in graphics form (USHEW, 1978). In terms of the model this can be seen quite simply as an appeal by these people to lower the cost of processing information. Another conclusion from the hearings was that those with special dietary needs were most willing to incur extra costs to obtain information. This would be expected since these individuals would have a higher EL and consequently a higher demand for information.

III. An Application of the Model

A. Background

The model and theory developed in this paper are meant to be generally applicable to all types of information and data pertaining to food products. The type of data most frequently discussed thus far is nutritional data, but unfortunately at the present time the author is not aware of any nutritional data that would enable a direct application of the model. A type of product information that can be analyzed, however, is weight information. Some foods, specifically meats and poultry, tend to accumulate moisture in the packing process. If the weight of this moisture is included in the weight of the product appearing on the package label, the label weight will tend to overstate the true amount of product contained in the package.

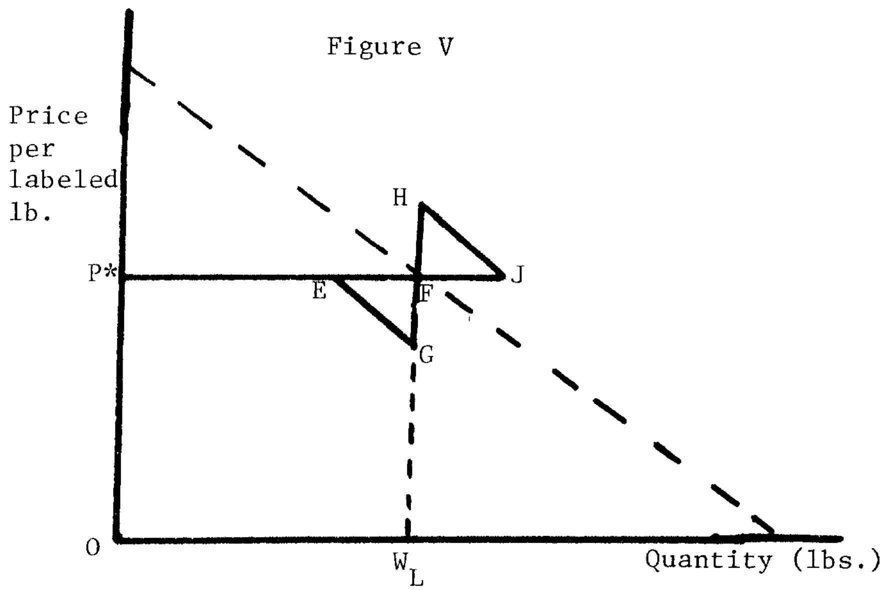
Proposed federal regulations (USDA,1979_1) will require that on average the drained weight of the product (the product minus accumulated moisture--essentially the amount of pure product) be equal to or greater than the label weight. However, for any particular package, depending on the amount of moisture accumulation, the label weight may be greater or less than the drained weight. Most states allow a "dry tare" approach to be used in determining label weight. With this method the label weight is determined by subtracting the weight of the packaging material (the dry tare) from the weight of the total package, and this results in the moisture being included in the label weight. A few states (California, Washington, and Michigan in particular) require that the label weight be based on the drained weight of the product. In any case the actual drained weight of the product in a package may be more or less than the weight specified on the label. Thus the consumer of any given package may receive more or less a pure product than he/she had anticipated based on the labeled weight. This is a problem of imperfect information quite suited to analysis within the model developed previously.

The data to be analyzed consist of 406 packages of chicken sampled by USDA researchers at retail outlets across the nation. Researchers obtained the label weight for each package, then drained the moisture from each one and reweighed it enabling them to measure the amount of moisture accumulation in each package. The data were collected by USDA (1979_2)in several states including some states which require drained weight labeling and some which allow dry tare labeling. With this data it is possible to obtain an estimation of loss due to imperfect weight information and derive a rough representation of the benefit to consumers from improved weight information.

B. Empirical framework

For each of the 406 packages of chicken we have labeled weight (W_L), drained weight (W_D) and price per labeled lb. (P*). From each package using P* and W_L a point in Euclidean two space somewhere on the demand surface can be obtained. This is shown as point F on Figure V.

Figure V



To apply the model to this data it is necessary to be able to estimate the triangular areas of consumer loss GEF and FHJ as illustrated on Figure V and developed earlier in Figure I. No information exists about the demand functions of individual consumers purchasing chicken. However, assuming the packages of chicken sampled are representative of packages of chicken sold, a demand curve going through some point such as F can be assumed to exist as indicated on Figure V. The demand elasticities used in this study are the national market price elasticities of consumer demand for chicken estimated by Brandow (1961) and George and King (1971).

In outlining the empirical framework assume for convenience that the consumer has perfect information about the nature of all the product's attributes except weight. In the case where $W_D > W_L$, given the above assumption, the consumer will be underevaluating the product (possibility 2, page 10) since there is more of the product, and hence more of the product's attributes, contained in the package than the consumer has been led to believe from the information available--namely the labeled weight. The loss to the consumer from this underevaluation is FHJ. To estimate FHJ, HF and FJ must be found.

The procedure used to find HF is as follows:

1.0 $W_D - W_L = W_S$, where W_S is in this case the surplus amount of product the consumer receives over and above the amount specified on the label. When $W_D < W_L$, W_S is the amount by which the product is deficient.

The consumer should be willing to pay some amount for W_S. Assume he/she is just willing to pay P* for an amount up to W_L. Therefore, the consumer is willing to pay less than P* for amounts greater than W_L since the demand curve is downward sloping. Employing this concept it is possible to arrive at a formulation to measure the consumer's additional willingness to pay <u>per labeled pound</u>. This then is HF. The reader should consult the appendix for a more detailed exposition of the steps taken in arriving at HF

1.1 $$HF = \frac{P^*W_S}{2W_L}\left(2 - \frac{W_S}{EcW_L}\right)$$ where Ec = the elasticity coefficient from the assumed demand relationship (see p. 28).

FJ is found as follows:

2.0 P^*W_L = purchase price/pkg.

2.1 $\frac{P^*W_L}{W_D}$ = effective price/lb.

$$2.2 \quad \frac{P^*W_L}{W_D} - P^* = \text{effective change in price/lb.}$$

When $W_L \neq W_D$ the label price per lb. and the actual or effective price per lb. are not the same. The result is an effective price change. When $W_D > W_L$ the result is an effective price decrease as indicated in step 2.2. A price change will always lead to a change in quantity demanded (Q) for any product whose demand elasticity coefficient is other than 0. FJ is the additional amount of product the consumer would purchase given the effective price decrease. Solving for the change in Q will yield FJ. This is done by employing the elasticity formula, $Ec = \frac{\Delta Q}{\Delta P}\frac{P}{Q}$, making the appropriate substitutions ($\Delta P = P^*(\frac{W_L}{W_D} - 1)$, $P = P^*$, $Q = W_L$) and solving for ΔQ. When simplified the following expression is obtained (the steps in arriving at FJ are also delineated in more detail in the appendix):

$$2.3 \quad FJ = \Delta Q = EcW_L(\frac{W_L}{W_D} - 1).$$

To estimate the area of FHJ the triangle area formula is employed to obtain:

$$3.0 \quad L_{FHJ} = 1/2HF(FJ) \qquad \text{where } L_{FHJ} = \text{the loss from underevaluation.}$$

The opposite case a consumer can encounter is where $W_D < W_L$. Here the consumer will be overevaluating the product (possibility 1, p. 10). Based on the labeled weight she/he will think the product contains more than it actually does. The loss from overevaluation is GEF (Figure V). The method employed to estimate this loss is completely analogous to the technique outlined for estimating FHJ and hence is not delineated here. Let it suffice to say that had the consumer known the weight deficiency, he/she would have been willing to pay less per labeled pound for the product enabling FG to be obtained. Also the weight deficiency results in an effective price increase which would lead to a decrease in Q enabling one to obtain EF. The loss from overevaluation is therefore:

3.1 $L_{GEF} = 1/2EF(FG)$ where L_{GEF} = the loss from overevaluation.

C. Empirical results

In this instance the equation to estimate a loss from overevaluation, L_{GEF}, is the same as that used to estimate a loss from underevaluation, L_{FHJ}, so a single equation can be employed to estimate the losses from imperfect weight information. The equation obtained through combining and simplifying the expressions outlined in 1.1 and 2.3 is

$$4.0 \quad L = \frac{P^*W_S}{4}\left(\frac{W_L}{W_D} - 1\right)\left(2Ec - \frac{W_S}{W_L}\right).$$

See the appendix for the algebra involved in the simplification.

Six runs of the analysis were made. The results are summarized in Table 1. Results were obtained for the entire sample using (a) Brandow's elasticity estimate (Ec = -1.16) and (b) George and King's estimate (Ec = -.78). Results were also obtained by dividing the sample into two parts, data from states which have drained weight labeling regulations and data from those states which do not have such regulations. These subsamples were each analyzed separately using both elasticity estimates. Two observations from the drained weight states subsample appeared to be outliers. Both observations exhibited $W_L > W_D$ by a substantial amount due either to mislabeling or sampling error--although there was no evidence of such error. If these cases resulted from mislabeling they represent legitimate consumer losses and would be valid, although extremely influential observations. If

Table 1

Run	(1) Sample Size (n)	(2) Numbers of cases where $W_D > W_L$ [1/]	(3) Numbers of cases where $W_D < W_L$ [1/]	(4) Loss to Consumers (L)	(5) Total expenditure from sample $TE = P*W_L$	(6) Loss as a proportion of expenditure LPE = L/TE
Full sample Ec = -1.16 (Brandow)	406	198	203	$0.3872	$1058.21	.0003659
Full sample Ec = -.78 (Geo. & King)	406	198	203	0.2649	1058.21	.0002503
Nondrained weight states Ec = -1.16	123	7	114	0.1147	336.32	.0003410
Nondrained weight states Ec = -.78	123	7	114	0.0776	336.32	.0002307
Drained weight states Ec = -1.16	283	191	89	0.2725	721.89	.0003774
Drained weight states Ec = -1.16 [2/]	281	191	87	0.1096	715.97	.0001530
Drained weight states Ec = -.78	283	191	89	0.1873	721.89	.0002594
Drained weight states Ec = -.78 [2/]	281	191	87	0.07370	715.97	.0001029

[1/] The observation in columns 2 and 3 may not total the sample size (column 1) since in a few cases $W_L = W_D$.

[2/] Influential cases dropped.

the error was made in the sampling process the cases are, of course, invalid. Since their exact cause is uncertain the results of the analysis for the drained weight states with these cases omitted are also included in Table 1.

The first three columns of the table are self explanatory. Column 4 (loss to consumers) is the result obtained from applying equation 4.0 to each observation and summing over all the included observations. Column 5 (total expenditure) is simply the amount consumers would have had to pay at retail for the sum of the observations included in the particular run. And Column 6 (loss as a proportion of expenditure) is obtained by dividing the loss from each run by the total expenditure (column 5) for that run.

D. Interpretation of results

Caution needs to be exercised in interpreting the results of the application due to the small size of the data set and some rather strong assumptions necessary to fit this particular data set to the model. At first glance the actual losses to consumers seem quite small, but when one considers the total amount spent on chicken in particular and other meats and poultry in general, these types of losses can be significant. For instance per capita chicken consumption in the U.S. in 1978 was 47.7 lbs., the average price was $0.66/lb. meaning that on average U.S. consumers spent about $31.72 per capita on chicken in 1978. Taking the liberty of projecting the results from this sample to these 1978 consumption figures, a crude estimate of the annual loss from imperfect weight information on chicken can be obtained. Multiplying the per capita expenditure figures by the approximate U.S. population and then multiplying by the loss as a proportion of expenditure (LPE) figures from column 6 of Table 1 gives a loss to consumers of about 2,550,000 dollars when LPE = .0003659 (full sample using Ec = -1.16). The loss is about 1,740,000 dollars when .0002503 is used as LPE (full sample using Ec. = -.78).

It should be noted that the procedure used to obtain these results necessarily represents some departure from the model's basic theory. Loss from imperfect information is unique to each consumer based upon his/her demand for the product, the information at each's disposal, etc. The only theoretically correct way to measure this loss is with the individual consumer as was done in the model where individual demand curves led to obtaining an EL for the individual which led to obtaining the MB of information for the individual. Aggregation was done only in the final step where the individual MB_i's were summed to obtain an aggregate benefit figure from information provision. In this application it was necessary to begin with an aggregate demand curve and assume its applicability to the individual consumer. The loss figures from the individual packages were then summed to obtain the total loss (L) figure. Essentially the basic difference is that aggregation is utilized at the beginning in the application rather than only at the end as the model mandates.

The figures obtained for dollar losses from imperfect weight information also can be interpreted as the value to consumers of improved weight information. Figures of this sort have obvious significance in terms of cost-benefit measurement for programs designed to improve label information to consumers. For convenience one can take the simple average of the two loss figures obtained to give a single loss formulation, (2,550,000 + 1,740,000)/2 = 2,145,000. Figures of this sort could then be compared with the costs incurred by sellers in providing new data and by consumers in processing it to determine if there are net benefits or net costs generated by imposing the additional disclosure. In this particular example processing costs to consumers are probably 0 since there would be no new information on the label, only a more accurate representation of the product weight. So, again assuming the loss figure $2,145,000 is somewhat valid, if processors could provide improved weight information of the type discussed here at an annual cost of less than 2,145,000, it can be concluded that it would be beneficial to have them do so.

As another example it would be possible for all states to require a drained weight labeling system as is done in some states. Taking the average of the LPE's obtained from the drained weight states with the influential outlying cases dropped (rows 6 and 8 of Table 1) and multiplying by total national expenditures gives an approximate annual loss of 890,000 dollars. If such a system was imposed nationwide the reduction in loss would be 2,145,000 - 890,000 = 1,255,000 dollars. Therefore, if a drained weight labeling system for chicken could be imposed nationwide at an annual cost of less than 1,255,000 it would be socially beneficial to do so.

The results also indicate that in states which impose drained weight labeling regulations overevaluation seems less likely to occur (note column 3 from Table 1) and when the influential cases are removed LPE becomes considerably less in these states also. To test for significance of differences between the two subsamples, the absolute values of the W_S were summed for each subsample. The mean value for $|W_S|$ was .0569 lbs. for the nondrained weight states and .0431 lbs. for the drained weight states. A t test for significant differences between sample deviation proportions produced a $t = 2.86$, significant at a .01 level of confidence indicating that the mean deviation between W_D and W_L was significantly less in states which had a drained weight labeling system.

It should also be noted that losses are greater when the larger elasticity coefficient is used. This result will be true in general since differentiating the loss equation (equation 4.0) with respect to Ec gives

$$5.0 \quad \frac{\partial L}{\partial Ec} = \frac{-W_S P^*}{2} \left(\frac{W_L}{W_D} - 1\right)$$

the value of which will always be positive for $W_L \neq 0$. The minus sign at the front of the expression is due to Ec always being a negative term. When $W_L > W_D$, W_S is negative making the first term in the expression positive. In the second term $W_L/W_D > 1$ makes that term positive also. When $W_L < W_D$, W_S is positive making the first term negative. The second term is negative also since $W_L/W_D < 1$, so the signs cancel out.

IV. Some Policy and Empirical Recommendations

The theoretical development in this paper indicates that in general consumers can expect to incur some dollar loss in economic welfare in any purchase situation in which they possess less than perfect information. The more information a consumer processes the less will be the expected loss. However, policy designed to simply put more and more product data before consumers is not necessarily advisable. The costs to producers in generating the data and to consumers in processing it must be considered. More attention should be concentrated on the format of presentation in order to reduce these costs and in turn encourage more provision and processing of data. As such the following specific types of policy recommendations pertaining to food labeling would seem to be in order. FDA should consider the effectiveness of alternative presentation formats as a means of reducing processing costs. Programs of nutritional education should be considered also as a means of reducing processing costs. Also consumers should be made aware of losses they may incur from lack of information. If they fail to recognize these losses, they will not demand information. Finally, provision of still more label data is not likely to be a good idea until consumers have learned how to use the data currently at their disposal. Further provision at this time could lead to information congestion and raise processing costs. No specific recommendations can be made from the application of the model to the weight data since no information is presently available on the costs involved in providing more accurate weight data.

In terms of empirical analysis I would suggest that the following questions need to be answered in the approximate order of their listing. As will be noted work on some of these questions has already been done or is currently underway.

1. What foods have nutritional labels and what percentage of total food expenditure is on foods which provide nutritional labeling? Surprisingly this is not known but FDA is investigating the question.

2. Have nutritional labeling requirements directly or indirectly made foods more nutritious or expensive?

3. Is there a relationship between price and nutrient content of brands of foods?

4. Do most consumers have a desire for the type of data supplied through labeling requirements? The model presented previously indicates they should, and existing studies seem to indicate they do.

5. What percentage of data on labels is understood, and would different formats of presentation increase understanding? Existing studies indicate a large lack of understanding and much confusion regarding some of the data currently provided. There is no substantial evidence regarding the effectiveness of alternative presentation formats.

6. What are the benefits and costs associated with specific types of label disclosure programs? This paper developed a mechanism for analyzing the benefits from obtaining information and made an initial estimation of such benefits with the weight application.

7. Has the provision of potential information on food labels altered consumer purchasing decisions? This is a key question and evidence to date suggests consumers will alter their buying decisions based upon this type of information. The Redbook survey (1976) reported 50% of women stopped or cut back on purchases of a food because of high sugar, 39% due to high cholesterol and 29% because of additives. However, no evidence has been presented to show that provision of label data has significantly altered demand for any specific food products.

8. What are the indirect costs and benefits which result from label regulations, and how important are they? Many such effects have been postulated, but discussion of them in this paper has been avoided in an attempt to maintain some degree of conciseness.

V. Summary

The concern of this paper has been with product information in general and nutritional information (labeling) on food products in particular. In section I the studies cited indicated that most consumers do desire and would be willing to pay for information of the type attainable from the standard nutritional label which appears on many food products. These same studies, however, indicated that often consumers were apparently not presently making use of such data.

In section II a model was presented which developed a theoretical framework for explaining and analyzing the information problem. It was shown that in the absence of perfect information about a product consumers incur some expected dollar loss (EL) from expenditure misallocation. It was then demonstrated that this EL leads to a demand for information by consumers who would rationally be willing to pay for information an amount equal to the reduction in EL that would be generated from it. Finally, it was shown that both producers and consumers incur costs in providing data and processing information respectively. These costs place limitations on the amount of data voluntarily provided and the amount of information processed.

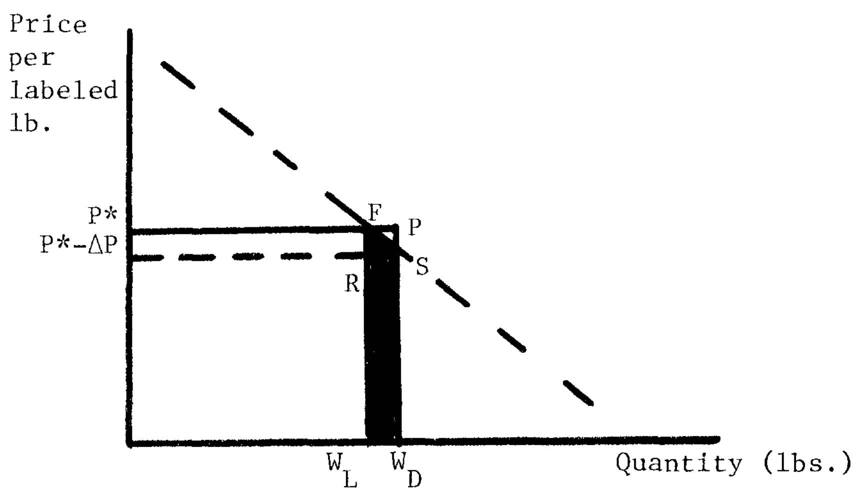
In section III the model was applied to a specific case of imperfect information. Data indicated that the labeled weight for packages of chicken could be either greater or less than the actual drained weight of the product. It was shown that consumers would incur a loss in either case.

VI. Appendix

A. Computations to obtain equation 1.1.

Of interest is the consumer's additional willingness to pay for W_S. This willingness to pay is shown by the shaded area in Figure A1. This area

Figure A1



is found by computing the average of areas W_LFPW_D and W_LRSW_D, $W_LFPW_D = P^*W_S$ since $W_S = W_D - W_L$. To find W_LRSW_D it is necessary to solve for the change in price, ΔP, which is equal to PS from Figure A1. This is done by solving the elasticity formula, $Ec = \frac{\Delta Q}{\Delta P}\frac{P}{W}$, for ΔP. Solving for P gives $\Delta P = \frac{\Delta Q}{Ec}\frac{P}{Q}$.

Now substituting in W_S for ΔQ, W_L for Q and P* for P yields $\Delta P = \frac{W_S P^*}{EcW_L}$.

The area W_LRSW_D is then equal to $(P^* - \frac{W_S P^*}{EcW_L})\, W_S$. The average of the areas is then $\frac{W_LFPW_D + W_LRSW_D}{2} = \frac{P^*W_S + (P^* - W_SP^*/EcW_L)\, W_S}{2}$. Factoring out P* and W_S yields $\frac{W_LFPW_D + W_LRSW_D}{2} = \frac{W_SP^*}{2}(2 - \frac{W_S}{EcW_1})$. This gives the total willingness to pay for W_S. In order to find how much more the consumer would be willing to pay per labeled pound if he/she knew that the actual weight of the product was $W_L + W_S$, divide the expression through by W_L giving

$$\text{1.1} \qquad HF = \frac{P^*W_S}{2W_L} \left(2 - \frac{W_S}{EcW_L}\right)$$

where HF is the additional willingness to pay per labeled pound as indicated in Figure V.

B. Steps to obtain equation 2.3.

It is necessary to solve the elasticity equation for $\Delta Q = Ec\Delta P \frac{Q}{P}$,

where $\Delta P = P^*W_L/W_D - P^*$ (from expression 2.2)

$P = P^*$

$Q = W_L$

Therefore, $FJ = \Delta Q = Ec(P^*W_L/W_D - P^*)\ W_L/P^*$.

Factoring out P* and cancelling yields

$$\text{2.3} \qquad FJ = \Delta Q = EcW_L \left(\frac{W_L}{W_D} - 1\right).$$

C. Steps to obtain equation 4.0.

Initially substitute equations 1.1 and 2.3 into the triangle area formula:

$$L = 1/2 \left[\frac{P^*W_S}{2W_L} \left(2 - \frac{W_S}{EcW_L}\right)\right] \left[EcW_L \left(\frac{W_L}{W_D} - 1\right)\right].$$

Employ the associative law of multiplication and combine $\frac{P^*W_S}{2W_L}$ with EcW_L and cancel the W_L's. This gives

$$L = \left(\frac{P^*W_S}{4}\right) Ec \left(2 - \frac{W_S}{EcW_L}\right) \left(\frac{W_L}{W_D} - 1\right).$$

Multiply the middle term through by Ec and cancel, which yields

$$\text{3.0} \qquad L = \left(\frac{P^*W_S}{4}\right) \left(\frac{W_L}{W_D} - 1\right) \left(2Ec - \frac{W_S}{W_L}\right).$$

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