AgEcon Search Appendix to "Welfare Effects of Food Labels and Bans with Alternative Willingness to Pay Measures," to appear in

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Here we provide more detail on precisely how welfare measures from each of the preference elicitation methods can be calculated.

Method 1: Discrete choice

Consider studies in which consumers are asked to indicate which product (or none) they would purchase given price and quality levels. Data from such studies are typically analyzed using random utility theory in which the indirect utility function for individual *i* is given by: $V_{iR} = \alpha_R + \beta P_{iR} + \varepsilon_{iR}$ if the regular product is purchased, $V_{iN} = \alpha_N + \beta P_{iN} + \varepsilon_{iN}$ if the new product is purchased, and $V_{iNone} = 0 + \varepsilon_{iNone}$ if neither the new or regular is purchased, where *P* is the price, and where α_k and β are coefficients typically obtained from estimating a conditional logit econometric model or some variant on this model. Marginal WTP for the new quality is typically calculated and reported as $-(\alpha_N - \alpha_R)/\beta$. Although this statistic is useful in many situations, it does not necessarily indicate the welfare effects of food policies.

First, consider the welfare effects of a ban on uninformed consumers. Assuming a conditional logit model was used to analyze the data, aggregate demand for the regular good (prior to introduction of the new good) is:

$$D_{L,R}(P_1) = N\frac{e^{\alpha_R+\beta P_1}}{e^{\alpha_R+\beta P_1}+1}, \tag{A1}$$

where the L subscribe indicates the logit demand, and where N indicates the number of choices made by all consumers in a given period. The uninformed consumer is unaware, however, that the new good is now being sold, but they do realize the price has fallen from P_1 to P_0. This means that aggregate demand for the good by uninformed consumers is:

$$D_{L,R}(P_0) = N\frac{e^{\alpha_R+\beta P_0}}{e^{\alpha_R+\beta P_0}+1}. \tag{A2}$$

For uninformed consumers, a ban on the new product serves to increase the price from P_0 to P_1 (i.e., demand changes from equation (A2) to equation (A1) and the consumer simply moves along the demand curve), and the change in consumer surplus corresponds to the area to the left of the demand curve between the price change:

$$\Delta CS_{L.BP}^{UI} = \int_{P_0}^{P_1} N\frac{e^{\alpha_R+\beta P}}{e^{\alpha_R+\beta P}+1}dP = \frac{N}{\beta}\left[\ln(e^{\alpha_R+\beta P_1}+1)-\ln(e^{\alpha_R+\beta P_0}+1)\right], \tag{A3}$$

where $\Delta CS_{L.BP}^{UI}$ denotes the consumer surplus change, the subscript L denotes the logit model, the subscript BP denotes the ban policy, and the superscript UI denotes the uninformed consumer.

Leggett (2002) refers to the welfare change in (A3) as the "anticipated benefit" as it relates to the welfare change based on people's perceived (or, in this case, incorrect) beliefs about product quality. To more fully characterize the welfare change of the ban, one must also factor in the implicit welfare loss people experience from being uninformed – the cost of ignorance (Foster and Just, 1989). The derivations in Leggett (2002) indicate that the cost of ignorance is given by:

$$COI_{L.BP}^{UI} = \frac{N}{\beta}\left(\frac{e^{\alpha_R+\beta P_0}}{e^{\alpha_R+\beta P_0}+1}\right)\left[\alpha_N-\alpha_R\right]. \tag{A4}$$

Thus, the total welfare change of a ban for uninformed consumers is given by (A3) minus (A4).

Now, consider the welfare effects of a ban on informed consumers. Informed consumers realize that a ban would change the quality of the good, and as such, the demand curve shifts. In particular, before the ban, aggregate demand for the new good is:

$$D_{L,N}(P_0) = N\frac{e^{\alpha_N+\beta P_0}}{e^{\alpha_N+\beta P_0}+1}. \tag{A5}$$

After the ban, the utility parameter changes from α_N to α_R (i.e., the demand curve shifts), and price changes from P_0 to P_1 because the regular good is more costly to produce. This means that aggregate demand for the good by informed consumers after the ban is:

$$D_{L,R}(P_1) = N\frac{e^{\alpha_R+\beta P_1}}{e^{\alpha_R+\beta P_1}+1}. \tag{A6}$$

Thus, for informed consumers a ban results in the following consumer surplus change (see Small and Rosen, 1978 for details on the welfare calculation):

$$\Delta CS^{I}_{L.BP} = \frac{N}{\beta}\left[\ln(e^{\alpha_R+\beta P_1}+1)-\ln(e^{\alpha_N+\beta P_0}+1)\right], \tag{A7}$$

where the superscript I denotes the informed consumer.

Rather than banning a new product, regulators may be interested in preserving consumer sovereignty by requiring labels. When products are labeled, all consumers are informed of product quality, and aggregate demands for regular and new products are:

$$D_{L,R}(P_1) = N\frac{e^{\alpha_R+\beta P_1}}{e^{\alpha_R+\beta P_1}+e^{\alpha_N+\beta P_1}+1}, \tag{A8}$$

$$D_{L,N}(P_0) = N\frac{e^{\alpha_N+\beta P_0}}{e^{\alpha_R+\beta P_1}+e^{\alpha_N+\beta P_1}+1}.$$

If consumers are uninformed, the “anticipated” or perceived change in consumer surplus of a mandatory labeling policy is

$$\Delta CS^{UI}_{L.LP} = \frac{N}{\beta}\left[\ln(e^{\alpha_R+\beta P_1} + e^{\alpha_N+\beta P_0} + 1) - \ln(e^{\alpha_R+\beta P_0} + 1)\right]. \quad \text{(A9)}$$

One can also subtract the cost of ignorance given by equation (A4) from the measure in (A9) to arrive at the total welfare change accruing to uninformed consumers from a labeling policy. If consumers are fully informed, the change in consumer surplus resulting from the policy is:

$$\Delta CS^{I}_{L.LP} = \frac{N}{\beta}\left[\ln(e^{\alpha_R+\beta P_1} + e^{\alpha_N+\beta P_0} + 1) - \ln(e^{\alpha_N+\beta P_0} + 1)\right], \quad \text{(A10)}$$

where the subscript *LP* denotes the labeling policy.

Method 2: Individual WTP

The second approach focuses on methods where one obtains individual estimates on WTP. Let WTP_{iR} and WTP_{iN} indicate individual *i*'s willingness-to-pay for the regular and new qualities, respectively. These willingness-to-pay measures can be used to make welfare calculations. Consumer *i* derives utility, $WTP_{iR} - P_R$, if a unit of the traditional version of the good is consumed, $WTP_{iN} - P_N$ if a unit of the new good is consumed, and zero otherwise (i.e., the utility of non-purchase is normalized to zero).

If only the regular product is offered after the new-product ban, then an individual can one choose between two outcomes: regular at P_1 and none. The consumer chooses the option generating the highest utility, namely

$$CS_{A.i} = \max\{WTP_{iR} - P_1, 0\}, \quad \text{(A11)}$$

where the subscript *A* denotes auction or individual-WTP method. Thus, the consumer surplus change from a new product ban if all consumers are fully informed is

$$\Delta CS^{I}_{A.BP} = (N/L)\sum_{i=1}^{L}[\max\{WTP_{iR} - P_1, 0\} - \max\{WTP_{iN} - P_0, 0\}], \quad \text{(A12)}$$

where L is the number of participants in the experiment, and as in the previous section, N is the total number of choices made over the time period of interest.

If all consumers are uninformed, the "anticipated benefit" is:

$$\Delta CS_{A.BP}^{UI} = (N/L)\sum_{i=1}^{L}[\max\{WTP_{iR} - P_1, 0\} - \max\{WTP_{iR} - P_0, 0\}], \qquad \text{(A13)}$$

and the cost of ignorance is:

$$COI_{A.BP}^{UI} = (N/L)\sum_{i=1}^{L} I_{iR}[WTP_{iN} - WTP_{iR}], \qquad \text{(A14)}$$

where I_{iR} is an indicator variable taking the value of 1 if individual i is predicted to have chosen the regular product at P_0. The total surplus change for uninformed consumers is given by (A13) minus (A14).

Under a mandatory label, an individual can choose between all three products: regular, new, and none. She/he will choose the one which generates the highest utility, and thus,

$$CS_{A.i} = \max\{WTP_{iR} - P_1, WTP_{iN} - P_0, 0\} \ . \qquad \text{(A15)}$$

The consumer surplus change from a label if all consumers are fully informed is

$$\Delta CS_{A.LP}^{I} = (N/L)\sum_{i=1}^{L}[\max\{WTP_{iR} - P_1, WTP_{iN} - P_0, 0\} - \max\{WTP_{iN} - P_0, 0\}]. \quad \text{(A16)}$$

If all consumers are uninformed, the "anticipated benefit" is

$$\Delta CS_{A.LP}^{UI} = (N/L)\sum_{i=1}^{L}[\max\{WTP_{iR} - P_1, WTP_{iN} - P_0, 0\} - \max\{WTP_{iR} - P_0, 0\}]. \quad \text{(A17)}$$

Method 3: Average WTP with time-series demand

Policy makers often need to calculate the welfare effects of various policies, but either do not have access to the individual-level WTP data or the logit demand estimates, and only have access to information on average WTP for a change in quality.

Under the method 3, the demand of a representative consumer consists of the numeraire *v* and the quadratic preference for the market good of interest:

$$U(Q_R, Q_N, v, I) = aQ_R + (a - Ie)Q_N - b\left[Q_R{}^2/2 + Q_N{}^2/2\right] - \gamma Q_R Q_N + v\,, \qquad \text{(A18)}$$

The terms $a, b > 0$ capture the immediate satisfaction of the representative consumer from consuming quantities of the regular good, Q_R, and the new good, Q_N. The parameter γ measures the degree of substitutability between the two goods.

The parameter e represents an additional disutility (or the utility with $e<0$) linked to the new product. The effects of this disutility is captured by the term $-IeQ_N$. The parameter I represents the knowledge of the specific characteristic. If the consumer is not informed of the specific characteristic then $I = 0$. Conversely, $I = 1$ implies that the consumer is informed of the specific characteristic and can internalize the quality change and adjust consumption accordingly. The maximization of the utility function under a budget constraint yields a demand function for each consumer.

Under a new-product ban, Q_N is equal to zero and the inverse demand for the regular product is given by

$$p_1(Q_R) = a - bQ_R\,. \qquad \text{(A19)}$$

The parameters a and b can be determined by classical calibration methods using existing data on price elasticity of the demand and equilibrium prices and quantities of the regular product. Using existing data on the quantity $\hat{Q}_R$ of the regular product sold over a period, the average price P_1 observed over the period, and the direct price elasticity $\hat{\varepsilon} = (dQ_R / dP_1)(P_1 / Q_R))$ obtained from time-series econometric estimates, the calibration leads to estimated values for the demand equal to $1/\tilde{b} = -\hat{\varepsilon}\hat{Q}_R / P_1$ and $\tilde{a} = \tilde{b}\hat{Q}_R + P_1$. From (A18), the overall surplus for an economy is $U(Q_R, 0, R - P_1 Q_R, 0)$, where the income R in the budget constraint is not considered in the estimations.

When the new product is allowed, then $Q_N > 0$. As in the previous sub-sections, with the absence of labels we assume only new products are sold at price $P_0<P_1$. The overall demand of informed consumers with I=1 for the new product is

$$p_0(Q_N) = a - e - bQ_N, \qquad \text{(A20)}$$

Empirically, the parameter e is determined by average WTP data coming from a survey/experiment where information is revealed. The relative variation in WTP based on the survey/experiment provides a measure of the inverse demand shift, $\delta = (WTP^N - WTP^R)/WTP^R$. By using notations of introduced with method 1 (discrete choice), $WTP^N = -\alpha_N / \beta$ and $WTP^R = -\alpha_R / \beta$, which leads to

$$\delta = \frac{(\alpha_N - \alpha_R)}{\alpha_R}. \qquad \text{(A21)}$$

This value is independent of the price coefficient, β, which means that (A21) isolates the utility change for the new product. Now, note that the inverse demand curves can be viewed conceptually as maximum WTP curves, where the price can be replaced with WTP. Thus, using the inverse demands in equations (A19) and (A20), the relative price variation is equal to the inverse demand shift defined by $[p_0(Q_N) - p_1(Q_R)]/ p_1(Q_R) = \delta$, which, after manipulating equations (19) and (20) leads to the equality $e = -\delta p_1(Q_R)$.

The demand for new products with uninformed consumers is defined by $a - bQ_N$ when price is P_0 and a cost of ignorance equal to eQ_N because of the lack of awareness not internalized in the demand. The consumer surplus is $[U(0, Q_N, R - P_0 Q_N, 0) - eQ_N]$. With uninformed consumers, the consumer-surplus variation linked to a new-product ban is

$$\Delta CS_{T.BP}^{UI} = U(Q_R, 0, R - P_1 Q_R, 0) - \left[U(0, Q_N, R - P_0 Q_N, 0) - eQ_N \right], \tag{A22}$$

where the subscript T denotes the time-series model, the subscript BP denotes the ban policy, and the superscript UI denotes the uninformed consumer.

The demand for new products with informed consumers is defined by (A20). The consumer surplus is $U(0, Q_N, R - P_0 Q_N, 1)$. With informed consumers and a subscript I for informed, the consumer-surplus variation linked to a new-product ban is

$$\Delta CS_{T.BP}^{I} = U(Q_R, 0, R - P_1 Q_R, 0) - U(0, Q_N, R - P_0 Q_N, 1). \tag{A23}$$

We now turn to the scenario with mandatory label allowing the coexistence of cloned and regular beef. Beyond the representative consumer, total demand can be partitioned into two groups of consumers for the disutility. A proportion $(1-\beta)$ of consumers avoid cloned beef in lieu of the regular product with a disutility e_2. A proportion β of consumers choose the cloned beef because of the benefit of lower price with a disutility e_1 where $e_1 < e_2$ and $e = \beta e_1 + (1-\beta) e_2$ in (A20). The scenario with a new product signaled by a label (with I=1) leads to an inverse demand system for regular and new products

$$\begin{cases} p_1(Q_R) = a - b\overline{Q}_R - \gamma \overline{Q}_N. \\ p_0(Q_N) = a - e_1 - b\overline{Q}_N - \gamma \overline{Q}_R. \end{cases} \tag{A24}$$

$\overline{Q}_R, \overline{Q}_N$ are the quantities bought under a mandatory label.

The parameters e_1, γ are determined by using the equations (A22) and the given price P_0,P_1 linked to the supply. As *a* and *b* were previously determined in the initial calibration, and $\overline{Q}_R, \overline{Q}_N$ can be determined from the experiment/survey, the parameter γ is determined by solving, $P_1 = a - b\overline{Q}_R - \gamma\overline{Q}_N$. From the estimation of γ, the second equation $P_0 = a - e_1 - b\overline{Q}_N - \gamma\overline{Q}_R$ can be solved for finding e_1. From the experiment/surveys, it is possible to determine $\overline{Q}_R, \overline{Q}_N$ since we know the percentage M of consumers choosing regular products under the ban, namely $M = D_{L,R}(P_1)/N$ by using equation (A6) with method 1 (data from method 2 could alternatively be used). After the introduction of the new product and from the experiment/survey, we are able to determine the percentage $M_2 = D_{L,N}(P_0)/N$ of consumers choosing the new product, the percentage $M_1 = D_{L,R}(P_1)/N$ of consumers choosing regular product by using (A8). With the observed quantity $\hat{Q}_R$ of the regular product sold on the market before the introduction of the new product, the estimated equilibrium quantities $\overline{Q}_R, \overline{Q}_N$ used for determining are such that

$$\begin{cases} \dfrac{M_1 + M_2}{M} = \dfrac{\overline{Q}_R + \overline{Q}_N}{\hat{Q}_R} \\ \dfrac{M_1}{M_2} = \dfrac{\overline{Q}_R}{\overline{Q}_N} \end{cases} \qquad \text{(A25)}$$

With the estimation of $\overline{Q}_R, \overline{Q}_N$, the parameters e_1, γ can be calculated as described above. Note that this methodology under different contexts of information was not completely introduced before.

Under a mandatory label, consumers can choose between products and the surplus is $\beta \times U(0, \overline{Q}_N, R - P_0\overline{Q}_N, 1) + (1-\beta) \times U(\overline{Q}_R, 0, R - P_1\overline{Q}_R, 1)$.

The consumer surplus change from a mandatory label (with the subscript *LP*) if all consumers are fully informed (*I*=1) without a label is

$$\begin{aligned}\Delta CS_{T.LP}^{I} = {} & \beta \times U(0, \bar{Q}_N, R - P_0\bar{Q}_N, 1) + (1-\beta)\times U(\bar{Q}_R, 0, R - P_1\bar{Q}_R, 1) \\ & - U(Q_N, 0, R - P_0 Q_N, 1)\end{aligned} . \qquad \text{(A26)}$$

If all consumers are uninformed without a label (*I*=0), the consumer surplus is

$$\begin{aligned}\Delta CS_{T.LP}^{UI} = {} & \beta \times U(0, \bar{Q}_N, R - P_0\bar{Q}_N, 1) + (1-\beta)\times U(\bar{Q}_R, 0, R - P_1\bar{Q}_R, 1) \\ & - \left[U(Q_N, 0, R - P_0 Q_N, 0) - eQ_N \right]\end{aligned} . \qquad \text{(A27)}$$