WESTERN AGRICULTURAL ECONOMICS ASSOCIATION

PAPERS OF THE

1989 ANNUAL MEETING

WESTERN AGRICULTURAL ECONOMICS ASSOCIATION

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JULY 9-12, 1989

QUALITY CHANGES AND THE VOLUME OF TRADE

1. Introduction

With a few notable exceptions (e.g., Goddard, 1988; de Gorter and Meilke, 1986) agricultural economists have generally neglected quality differences between products in their theoretical or applied modeling of agricultural trade. Surprisingly, the work of Lancaster (1966, 1971) and Armington (1969) has not been as influential as perhaps it should have been. Of all possible markets, agricultural markets are certainly the ones where quality matters the most. In no other market are inspection and grading systems more important than in agricultural markets. The recent controversies about the use of growth hormones in beef production (U. of C. Berkeley Wellness Letter, 1989), the licensing of new wheat varieties in Canada (Gilmour, 1986), the inadequacy of the U.S. grain grading system (Hill, 1988) and the growing use of technical barriers to trade simply demonstrate the importance of quality in agricultural trade.

This paper addresses the question of how the volume of trade is affected by perceived changes in quality. A simple trade model is used to analyze the consequences of changes in the quality of imported goods from the importer's perspective. It is shown that when there is a constant quality relationship between domestic and foreign goods, the direction of the change in volume following a perceived exogenous improvement in the quality of an import good depends on the import price elasticity for that good.

The implications of the theoretical results derived below are far reaching. Governments in every countries have to make decisions regarding quality control. Some of the decisions deal with resource allocation for inspection and grading services, some relate to the licensing of new products and some are part of an export strategy focusing on product differentiation (and less on price competition). Product differentiation is not as transparent as price competition and probably less likely to trigger bitter responses. Consequently, the effects of perceived changes in product quality have to be investigated.

2. The Model

To analyze how perceived changes in quality affects the volume of trade, we chose to model the behavior of a "small" importing country. The importing country derives utility from two sources: the consumption of an aggregate good X, and the consumption of characteristics from the import good, say wheat. The domestically produced wheat is represented by Y while imports of wheat of quality q is labelled Q.

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The quality index q is defined in terms of the quality of the domestic wheat whose implicit quality parameter is one. The parameter q should be interpreted as the relative quality of imported wheat. Because q is a scalar, the quality trade off between foreign and domestic wheat is fixed thus reflecting perfect substitutability between one unit of domestic wheat and 1/q units of foreign wheat. Therefore, foreign and domestic wheat serve the same purpose and can be added on as one commodity[1]. The sum Y + qQ is the total amount of wheat characteristics available for domestic consumption. The world price for wheat of quality q is denoted by P and is determined by exogenous forces. G(Y) is the level of production of the aggregate good and it is assumed that an increase in wheat production can only be achieved at the expense of the production of the aggregate good (G_Y, $G_{YY} < 0$). Exports are defined as G(Y) - X and trade is balanced at all times (G(Y) - X = PQ). The utility maximization problem can be stated as follows:[2]

$$U(G(Y) - PQ, Y + qQ) \qquad (1)$$

The corresponding first order conditions for Y and Q are given by equations (2) and (3). Assuming the second order conditions hold (see Appendix), utility maximization implies:

$$U_1 G_Y + U_2 = 0, \qquad (2)$$

$$-U_1 P + U_2 q = 0, \qquad (3)$$

From (2), $U_2/U_1 = -G_Y$, or the domestic marginal rate of substitution equals the domestic rate of transformation. Similarly, from (3), $U_2 q/U_1 = P$ or the marginal rate of substitution of imported wheat for the aggregate good is equal to the relative price. Finally, from equations (2) and (3), we obtain an equality between the domestic rate of

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[1] Strictly speaking, bread wheat, pasta wheat and feed wheat are different commodities. Making the assumption that wheat is one commodity is in fact assuming that buyers of wheat serving different purposes are after the same characteristics and weight them in the same manner. Such an assumption is common in econometric modeling but clearly does not hold if the content of the quality reports published by the Canadian Grain Commission and U.S. Wheat Associates reflects the buyers' information requirements.

[2] An alternative specification has the budget constraint separated from the utility function by a Lagrangian multiplier in the following manner: $U(X, Y + qQ) + \Phi(G(Y) - X - PQ)$.

transformation and the world price weighted by the quality adjustment factor, $-G_Y = P/q$.

If consumers are capable of discerning quality variations, the real price P/q faced by the domestic wheat producers will internalize the consumers' ranking of wheats and will induce an adjustment in domestic production. For example, if the quality of the imported wheat is inferior ($q < 1$), the value of the domestic wheat will appreciate and its relative price will reflect the quality differential. As long as the buyers can discriminate among goods of different quality, there is no market failure and whether the domestic or foreign price adjust is irrelevant since it is the ratio of the two that matters. It should be stressed that this result holds only when the agents in the importing country know with certainty the relative quality of the imported wheat and can react instantaneously to quality changes.

3. Comparative Statics of Changes in Quality

The comparative statics for the model developed in above are revealing. Of principal interest is how the volume of imports and the consumption and production of domestically produced goods are affected by changes in the price and quality of imported wheat. These results are summarized below.

$$dQ/dP = U_1 [U_{11}G_Y^2 + U_{22} + 2U_{12}G_Y + U_1^2 G_{YY}] + U_1 QqG_{YY} [U_{11}P/q + U_{12}]/|A| < 0. \quad (4)$$

$$dY/dP = U_1 q [U_{11}G_Y P/q + U_{22} + 2U_{12}P/q]/|A| > 0. \quad (5)$$

$$dQ/dq = -U_2 [U_{11}G_Y^2 + U_{22} + 2U_{12}G_Y + U_1 G_{YY}] + U_1 G_{YY} qQ [U_{12}P/q + U_{22}] \gtrless 0. \quad (6)$$

$$dY/dq = [-U_2 q (U_{12}G_Y + U_{22})]/|A| < 0. \quad (7)$$

From the second order conditions derived in Appendix, we find that:

$$|A| = U_1 G_{YY} q^2 [U_{11}(P/q)^2 + U_{22} - 2U_{12}P/q] > 0. \quad (8)$$

As expected, equation (4) shows that as the price of imported wheat increases, the substitution and income effects move in the same direction, and demand for imported wheat decreases. Equation (5) shows that an increase in the price of imported wheat will increase the domestic

production of wheat, if the quality of imported wheat is held constant. When the price of imported wheat rises, the domestic producers of wheat augment their production and the consumers substitute the domestic wheat for the imported wheat.

The results in equations (4) and (5) are standard and can be found in most textbooks (e.g., Varian, 1984). The remaining results are interesting, since quality is not a characteristic for which extensive comparative statics analysis exists. Not surprisingly, it is demonstrated in equation (7) that when the perceived quality of imported wheat increases, the demand for domestic wheat falls. It is particularly important to note that equation (6) is ambiguous. When q (the quality variable) increases, fewer units of imported wheat are needed to achieve the same level of utility. In addition, decreasing marginal utility may result in the consumption of fewer units of imported wheat, and higher consumption of the aggregate good. The importing country, therefore, may achieve greater utility from purchasing a lower volume of wheat but will consume more wheat characteristics no matter how the volume changes. This is illustrated in Figures 1a and 1b. In both Figures, as the perceived quality of foreign wheat increases from q_0 to q_1, imports of wheat characteristics increases from Y_0X_0 to Y_1Z_1 and utility increases from U_0 to U_1. In Figure 1a, the volume of imports decreases from Y_0X_0 to Y_1X_1 as more of the aggregate good is produced and consumed. However, in Figure 1b, the volume of imported wheat and quality move in the same direction.

The necessary condition for signing equation (6) can be derived by first rewriting the utility function as

$$U = U(G(Y) - \delta\theta, Y + \theta), \tag{9}$$

where $\delta = P/q$ and $\theta = qQ$. Note, $d\delta/d\theta|q = (dP/dQ)/q^2$ which implies that $dQ/dP = [d\theta/d\delta]/q^2$. Therefore, $(d\theta/d\delta)\delta/\theta = (dQ/dP)P/Q = -\epsilon_Q$.[3] Equation (6) can be expressed as

$$dQ/dq = d(\theta/q)/d\delta \; d\delta/dq$$

$$= [d\theta/d\delta \; (-P/q) - \theta]/q^2$$

$$= (\epsilon_Q - 1)Q/q. \tag{6'}$$

The sign of (6) is hence positive if and only if

$$\epsilon_Q > 1. \tag{10}$$

Thus, it can be concluded that an improvement in the

[3] This can be verified by performing the comparative statics for the utility maximization problem in equation (9).

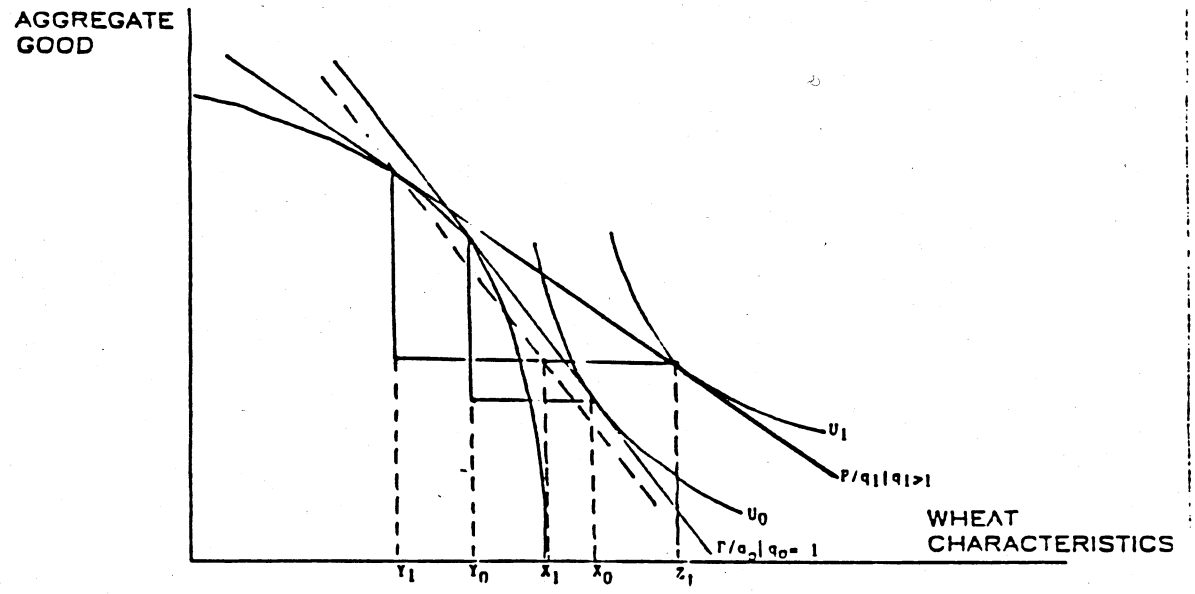

FIGURE 1B: WHEAT IMPORTS INCREASE FROM YoXo TO Y_1X_1 AND IMPORTS OF WHEAT CHARACTERISTICS INCREASE FROM YoXo TO Y_1Z_1 AS QUALITY INCREASES FROM qo to q1.

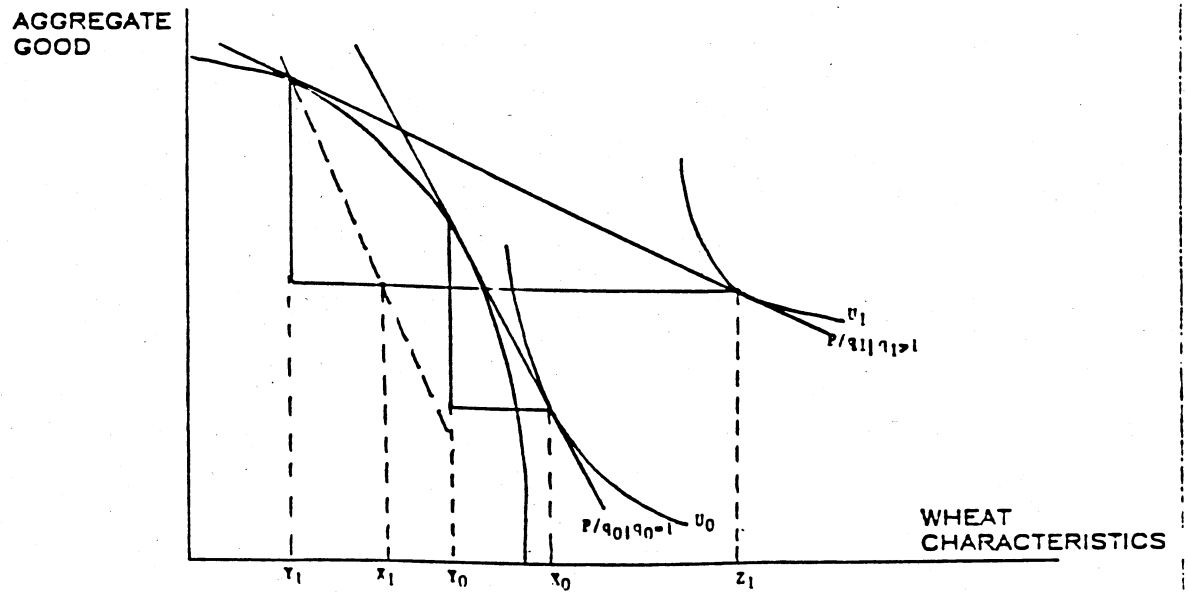

FIGURE 1A: WHEAT IMPORTS DECREASE FROM YoXo TO Y_1X_1 AND IMPORTS OF WHEAT CHARACTERISTICS INCREASE FROM YoXo TO Y_1Z_1 AS QUALITY INCREASES FROM qo to q1.

perceived relative quality of foreign wheat will lead to an increase in the volume of wheat imports if and only if the price elasticity of wheat imports exceeds one.

An alternative and more tedious approach uses the unambiguous sign of equation (4) to determine under what condition higher quality of imports will result in increased imports. Equation (6) can then be rearranged in the following manner.

$$dQ/dq = (dQ/dP)(-U_2/U_1) + [U_1 G_{YY} Qq\,(U_{12}P/q - U_{22}) + U_2 G_{YY} Qq\,(-U_{11}P/q + U_{12})]/|A|$$

$$= (dQ/dP)(-P/q) + Q/q\,[-U_1 U_{11} G_{YY} P^2 - U_1 U_{22} G_{YY} q^2 + 2U_1 U_{12} G_{YY} Pq]/|A|$$

$$= [(dQ/dP)(-P/q) - Q/q = (\epsilon_Q - 1)Q/q. \qquad (6'')$$

This is equivalent to the condition expressed in (6), and to take a positive value, again condition (10) $\epsilon_Q > 1$ must hold. Intuitively, an increase in q can be treated as an increase in the real price of domestic wheat P/q, also the price of the imported wheat when the latter is expressed in terms of the grade of the domestic wheat. Hence, the sign of (6') depends whether the demand for wheat is elastic or inelastic.

What is the implication of the result in (6'') for exporters of agricultural products? The import demand elasticities for beef (differentiated by country of origin) as computed by Goddard (1988) are concentrated between 0.5 and 2.0. If import decisions are made according to our model, it cannot be said that an importer will always buy more beef following an improvement in quality. For example, Japan is much more sensitive to a change in the price of U.S. beef ($\epsilon_Q = 1.810$) than it is for beef from New Zealand ($\epsilon_Q = 0.635$). On the other hand, the excess demand elasticities for wheat, coarse grains, rice, ruminant meat, non ruminant meat, dairy products and sugar as computed by Tyers and Anderson (1988) tend to be well above 1. Thus for this wide range of commodities, a perceived change in quality would cause the volume of trade to rise substantially.

The result shown in (6) was obtained by Murphy (1980) who used a characteristic model with exogenous income. Murphy's objective was to identify the relationship between quality and consumer demand. Like us, he demonstrated that the parameterization of quality in a demand equation could lead to erroneous results since an assumption has to be made about the effect of quality on demand. Equation (6'') is identical to his equation (11) and is unnecessarily tedious

to derive. The alternative proof given in (6') is derived in a much more intuitive and straightforward manner by exploiting the definition of δ.

4. Conclusion

The model introduced in Section 2 provided a basis for assessing the impact of changes in quality, when there is a fixed quality trade off between domestic and foreign wheat. The main result is the link between the import response to a change in product quality and the price elasticity of the imported good. Given a price inelastic import demand, imports will decrease when the quality of the imported product is upgraded.

5. References

Armington, P. S. "A Theory of Demand for Products Distinguished by Place of Production." I.M.F. Staff Papers. (March and July 1969):159-177.

Baron, D. P. "Price Uncertainty, Utility, and Industry Equilibrium in Pure Competition." International Economic Review, 11 (1970):463-480.

de Gorter, H. and K. D. Meilke. "The EEC's Wheat Price Policies and International Trade in Differentiated Products." American Journal of Agricultural Economics, 69 (1987):223-229.

Gilmour, B. "Medium Quality Wheat Production on the Canadian Prairies: Some Comments." Paper presented at the Canadian Regional Agricultural Model Workshop, Agriculture Canada, Ottawa, April, 1986.

Goddard, E. W. "Export Demand Elasticity in the World Market for Beef." In Elasticities in International Agricultural Trade. Edited by C.A. Carter and Gardiner W.H., Boulder, CO.: Westview Press, 1988.

Lancaster, K. "A New Approach to Consumer Theory." Journal of Political Economy, 74 (1966):132-157.

Lancaster, K. Consumer Demand. New York:Columbia University Press, 1971.

Murphy, M. "Quality and Consumer Demand." The American Economist, 24 (1980):42-45.

Tyers, R. and K. Anderson. "Imperfect Price Transmission and Implied Trade Elasticities in a Multi-Commodity World." In Elasticities in International Agricultural Trade. Edited by C.A. Carter and Gardiner W.H., Boulder, CO.: Westview Press, 1988.

Varian, H. R. Microeconomic Analysis. 2nd ed. New York: W. W. Norton & Co., Inc., 1984.

8. Appendix

For the second order conditions of the utility maximization problem to hold, the sign of the determinants of the Hessian matrix must alternate in sign (Varian, 1984). The Hessian matrix A can be constructed by totally differentiating the first order conditions as shown in (A1).

$$\begin{bmatrix} U_{11}G_Y^2 + U_1G_{YY} + 2U_{12}G_Yq + U_{22} & -U_{11}G_YP + 2U_{12}G_Yq + U_{22}q \\ -U_{11}G_YP + 2U_{12}G_Yq + U_{22}q & U_{11}P^2 - 2U_{12}Pq + U_{22}q^2 \end{bmatrix} \quad \text{(A1)}$$

The notation makes extensive use of subscripts which denotes partial derivatives, unless stated otherwise. For example U_{11} represents the second partial derivative of the utility function with respect to the consumption level of the aggregate good, X. Domestic and imported wheat (adjusted for quality differential) form the second argument in the utility function. The subscript '2' denotes a derivative with respect to wheat characteristics. The usual assumptions on the signs of U_{11} and U_{22} are made (i.e., $U_{jj} < 0$ for $j = 1$ or 2). This implies that utility is increasing at a decreasing rate as the consumption of wheat or the aggregate good increases. Barring saturation, the marginal utilities from the consumption of the aggregate good and from wheat are positive. By using results from the first order conditions and rearranging the terms, we obtain the following expression for the determinant of A. Since $G_{YY} < 0$, the expression $|A| = U_{11}U_1P^2G_{YY} - 2U_{12}U_1G_{YY}Pq + U_{22}U_1G_{YY}q^2$ is unconditionally negative when $U_{12} > 0$. When $U_{12} < 0$, the determinant of A will be negative if:

$$(-U_{11}P/q, -U_{22}q/P) > -U_{12}. \quad \text{(A2)}$$

(A2) is hence sufficient to guarantee that the second order conditions are met.