The Retail-Farm Price Ratio, the Farmer’s Share, and Technical Change

Allen K. Miedema


Stable URL:
http://links.jstor.org/sici?sici=0002-9092%28197611%2958%3A4%3C750%3ATRPRTF%3E2.0.CO%3B2-F

*American Journal of Agricultural Economics* is currently published by American Agricultural Economics Association.

Your use of the JSTOR archive indicates your acceptance of JSTOR’s Terms and Conditions of Use, available at http://www.jstor.org/about/terms.html. JSTOR’s Terms and Conditions of Use provides, in part, that unless you have obtained prior permission, you may not download an entire issue of a journal or multiple copies of articles, and you may use content in the JSTOR archive only for your personal, non-commercial use.

Please contact the publisher regarding any further use of this work. Publisher contact information may be obtained at http://www.jstor.org/journals/aaea.html.

Each copy of any part of a JSTOR transmission must contain the same copyright notice that appears on the screen or printed page of such transmission.

JSTOR is an independent not-for-profit organization dedicated to creating and preserving a digital archive of scholarly journals. For more information regarding JSTOR, please contact support@jstor.org.
The Retail-Farm Price Ratio, the Farmer’s Share, and Technical Change

Allen K. Miedema

Technical change in the food marketing industry has been causally linked to the secular increase in the marketing margin, i.e., the margin between product prices at retail and prices of the related raw farm products. Technical change has also been aduced by Lianos to explain the decline in the relative share of farm workers. However, this work generally omits a formal neoclassical model of technical change that accounts for imperfect competition in input and product markets.

This paper synthesizes previous work by Muth and by Gardner in developing a more complete specification of the effects of technical change. This specification allows for noninfinite product demand and factor supply elasticities. These theoretical results are then analyzed empirically to derive some specific quantitative implications of technical change for the food marketing industry. Lianos’ empirical estimate of the degree of capital-biased technical change in agriculture is reinterpret with these alternative neoclassical specifications.

A Synthesis of Previous Results

In a recent article in the Journal Gardner examined changes in input-retail price ratios and input shares induced by exogenous perturbations in product demand and in factor supply functions. The analysis was based on the standard one-product, two-input model. That model is first restated in a form that differs substantively from that given by Gardner. Another brief reformulation is given in logarithmic differentials as derived by Muth. With this reformulation Gardner’s main results can be reproduced and extended with simple recombinations of Muth’s results.

In the one-product, two-factor models equilibrium of the marketing industry is described by six equations: (a) a retail product (x) demand function (D); (b) a marketing industry production function (j), which is assumed to be linear homogeneous in the two inputs, a and b; (c) and (d) the marginal conditions on factor payments, i.e., equalities between factor prices (\(P_a\) and \(P_b\)) and the products of retail price (\(P_x\)) and marginal products (\(f_a\) and \(f_b\)); and (e) and (f) factor supply functions. These equations define the following system:

\[
\begin{align*}
(1) & & x = D(P_x), \\
(2) & & x = f(a, b), \\
(3) & & P_a = P_x f_a, \\
(4) & & P_b = P_x f_b, \\
(5) & & a = g(P_a), \\
& & b = h(P_b),
\end{align*}
\]

where \(x\) is food sold at retail. Prices are defined accordingly.

Muth has shown that equations (1) through (6) can be reformulated as

\[
(7) \quad ZY = R,
\]

where

\[
Z = \begin{bmatrix}
-1/\eta & 0 & 0 & 1 & 0 & 0 \\
1 & -k_a & -k_b & 0 & 0 & 0 \\
0 & k_b/\sigma & k_b/\sigma & -1 & 1 & 0 \\
0 & -k_a/\sigma & k_a/\sigma & 1 & 0 & 1 \\
0 & -1/e_a & 0 & 0 & 1 & 0 \\
0 & 0 & -1/e_b & 0 & 0 & 1
\end{bmatrix}
\]

\[
Y = \begin{bmatrix}
EX \\
Ea \\
Eb \\
EP_a \\
EP_b
\end{bmatrix}, \quad \text{and} \quad R = \begin{bmatrix}
\alpha \\
\delta \\
\delta + \epsilon \\
\delta - (k_a/k_b)e \\
\beta \\
\gamma
\end{bmatrix}
\]

The notation is defined in table 1. The complete mathematical derivations of the technical change parameters (\(\delta\) and \(\epsilon\)) are in Muth.

The solution of the system in equation (7) is \(Y = Z^{-1}R.\) Because of the way \(R\) is defined, \(Y\) may be

\[1\] None of these equations explicitly reflects its dependence upon any exogenous variables, but the presence of these exogenous variables in the demand, production, and factor supply functions is explicitly assumed. Following Muth, “the effect of changes in any such variables will be treated as a shift in one or more of these functions” (p. 222).

\[2\] Although Muth presents none of his work with matrix notation, the following matrix system is an exact restatement of his reformulated system. The five parameters (excluding \(k_a\) and \(k_b\)) in the vector \(R\) represent the combined shifting effects of the (omitted) exogenous variables in equations (1) through (6). Relative changes are defined as the logarithmic differentials of any variable. Thus, the relative change \(dt/t\) for an arbitrary variable \(t\) is the percentage change divided by 100.
Table 1. Variable Definitions

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>( EX )</td>
<td>( d(\ln x) = dx/x ) (the operator ( E ) is similarly defined for other elements of ( Y ))</td>
</tr>
<tr>
<td>( \eta )</td>
<td>Own price elasticity of demand for ( x )</td>
</tr>
<tr>
<td>( e_a )</td>
<td>Own price elasticity of agricultural commodity supply</td>
</tr>
<tr>
<td>( e_b )</td>
<td>Own price elasticity of marketing input supply</td>
</tr>
<tr>
<td>( \sigma )</td>
<td>Elasticity of substitution between ( a ) and ( b )</td>
</tr>
<tr>
<td>( k_a )</td>
<td>Cost share imputed to agricultural commodities</td>
</tr>
<tr>
<td>( k_b )</td>
<td>Cost share imputed to marketing inputs</td>
</tr>
<tr>
<td>( \alpha )</td>
<td>Relative change in food prices at any quantity on the new food demand curve</td>
</tr>
<tr>
<td>( \beta )</td>
<td>Relative change in the supply of ( a ) (the vertical relative shift in the supply function)</td>
</tr>
<tr>
<td>( \gamma )</td>
<td>Relative change in the supply of ( b )</td>
</tr>
<tr>
<td>( \delta )</td>
<td>Neutral component of technical change, defined as the relative (and equal) change in the marginal products of ( a ) and ( b ) (which is equal to the relative change in output) for the input quantities prior to the technical change</td>
</tr>
<tr>
<td>( \epsilon )</td>
<td>Factor-biased component of technical change, defined as the relative change in ( a )'s marginal product, holding output constant for the input quantities used prior to the technical change</td>
</tr>
</tbody>
</table>

redefined as a linear function of the vector of exogenous perturbations \( S \):

\[
Y = Z^{-1}R = \Delta^{-1}GS,
\]

where \( \Delta = \sigma_\eta - \sigma(k_a e_a + k_b e_b) + \eta(k_a e_a + k_b e_b) - e_a e_b \), usually a negative scalar defined by \( D^\nu \) in Muth and by \( -D \) in Gardner, \( G = [g_{ij}] \), a \( 6 \times 5 \) matrix whose row elements are directly available as the coefficients (excluding \( D^\nu \)) of the five elements of \( S \) in equations (24) through (29), respectively, of Muth's appendix, and \( S = (\alpha, \beta, \gamma, \delta, \epsilon)^t \).

To examine the shifting effects of exogenous variables in the food demand function, the agricultural commodity supply function, and the marketing input supply function, Gardner inserted three shift variables—\( N \), \( W \), and \( T \), respectively—into those functions. Therefore, the following three parameters appear in his main results:

\[
(9) \quad \eta_N = d(\ln x)/d(\ln N); \quad e_W = d(\ln P_g)/d(\ln W); \quad \text{and} \quad \epsilon_T = d(\ln P_g)/d(\ln T).
\]

Muth, on the other hand, expressed the product demand and factor supply function shifts—\( \alpha \), \( \beta \), and \( \gamma \), respectively—as \( \text{ad valorem} \) shifts in the direction of the price axis. Thus, he defined \( \alpha \) as the "relative increase in price at any given quantity on the new demand schedule" (Muth, p. 223). The parameters \( \beta \) and \( \gamma \) are accordingly defined as the relative increases in the supply prices of factors \( a \) and \( b \), respectively, at any given quantity. Therefore, Muth's shift coefficients may be expressed in terms of Gardner's three parameters in equation (9) as

\[
(10) \quad \alpha = -\left(\frac{\eta_N}{\eta}\right) d(\ln N) \quad \beta = e_w\, d(\ln W) \quad \text{and} \quad \gamma = e_T\, d(\ln T).
\]

The appropriateness of these expressions, which follow from the inverse functions related to equations (1), (5), and (6), may be verified in Muth.

Since Gardner did not consider the effects on the factor share of agricultural commodities resulting from an exogenous shift in the marketing input supply function, that analysis is presented here for completeness. It follows definitionally that

\[
(11) \quad d(\ln k_a/\gamma) = \left(\frac{g_{53} + g_{25} - g_{23} - g_{13}}{\Delta}\right) \text{ for } S = (0, 0, \gamma, 0, 0)^t, \quad \text{and} \quad \Delta = [(1 - \sigma)k_a e_a (e_a - \eta)/\Delta].
\]

Since \( \Delta \) is usually negative, the sign of equation (11) is determined by the size of \( \sigma \), as is the case for the change in \( a \)'s share resulting from a shift in the agricultural commodity supply function (see Gardner's equation (23)). If \( \sigma < 1 \), the farmer's share will fall as the marketing input supply function shifts upward. For example, if skilled labor specific to farm product marketing, e.g., butchers, were to become relatively scarcer, the marketing input supply function would shift upward and the farmer's share of the food dollar would decline. In any event identical conditions on the value of \( \sigma \) insure (except when \( \sigma = 0 \)) opposite directional effects on the farmer's share from exogenous perturbations of the agricultural commodity supply function and of the marketing input supply function, respectively.

The Effects of Technical Change

Since Muth's formulation contains two additional shift parameters relating to neutral and factor-biased technical change, respectively, the model is extended to examine their effects on the retail-farm price ratio and on input shares. This approach allows the relaxation of the traditional assumption of infinite product demand and factor supply elasticities in the analysis of the effects of technical change.

The two shift parameters (\( \delta \) and \( \epsilon \)) decompose the components of technical change in the marketing industry into intensity and bias, respectively (table 1). Although both parameters are defined at the pretechnical change equilibrium position that is a disequilibrium position after the technical change, they completely describe the change in the shape of the production isoquants. Just as Gardner's results and equation (11) summarize the new equilibria that result from changes in the shape of the product demand and input supply functions, a similar analysis summarizes the new equilibria that result from a change in the shape of the production isoquants.

---

1 Transformed back to Gardner's notation using the expression for \( \gamma \) from equation (10), this result can be restated as \( E_{wT} = -e_T \).
Technical Change and the Retail-Farm Price Ratio

The effect of neutral technical change on the retail-farm price ratio is derived from equation (8) as

\[ \frac{d\ln(P_{x}/P_{a})}{\delta} = \frac{(g_{a4} - g_{a5})}{\Lambda}, \]

for \( S = (0, 0, 0, \delta, 0)^{\prime} \),

\[ = \Lambda/\Delta, \]

where \( \Lambda = \sigma k_{a} e_{a} + k_{b} e_{b} + k_{d}(e_{a} - e_{b}) + e_{a} e_{b} - \gamma(\sigma + e_{a}). \)

There are four feasible values of parameter combinations in equation (12) to explore in completely examining the directional impact of neutral technical change on the retail-farm price ratio. All such evaluations recognize that \( \Delta \) is negative.

Case 1: \( e_{a} > e_{b} \) or \( e_{a} = e_{b} \). When the elasticity of agricultural commodity supply exceeds (or equals) that of market input supply, all terms in the numerator (\( \Lambda \)) of equation (12) are positive. The whole expression is negative for normal values of the parameters, so that the retail-farm price ratio declines with neutral increases in factor productivity when \( e_{a} > e_{b} \) or when \( e_{a} = e_{b} \).

Case 2: \( e_{a} < e_{b}, \sigma > 1. \) Since both \( e_{a} \) and \( e_{b} \) are positive and \( e_{b} \) is assumed less than \( e_{a} \), \( e_{a} \) can be expressed as a fraction \( \tau \), which lies in the open interval \((0, 1)\), of \( e_{b} \):

\[ e_{a} = \tau e_{b}, 0 < \tau < 1. \]

When the expression for \( e_{a} \) in equation (13) is substituted into the numerator (\( \Lambda \)) of equation (12) the numerator becomes

\[ \Lambda = \lambda_{0} + \lambda_{1} \tau, \]

where \( \lambda_{0} = k_{d} e_{b}(\sigma - 1) - \eta(\sigma + e_{b}) \) and \( \lambda_{1} = \sigma k_{a} e_{b} + k_{b} e_{b} + e_{b}^{2} \). When \( \sigma > 1, \lambda_{0} > 0 \) for all normal parameter values; also \( \lambda_{1} > 0 \) normally. Therefore, even when \( e_{a} < e_{b} \), the retail-farm price ratio declines with neutral increases in factor productivity when \( \sigma > 1 \).

Case 3: \( e_{a} < e_{b}, \sigma < 1, - (\lambda_{0}/\lambda_{1}) < 1, - (\lambda_{0}/\lambda_{1}) < \tau < 1. \) Since \( \Lambda \) is an increasing linear function of \( \tau \). \( \Lambda \) assumes positive values for all \( \tau > -(\lambda_{0}/\lambda_{1}) \). If \( -(\lambda_{0}/\lambda_{1}) < 1 \), there is some range of values for \( \tau \) that implies a positive numerator in equation (12), namely, the range of values for which \( \tau > -(\lambda_{0}/\lambda_{1}) \). When \( \lambda_{0} > 0 \), despite the fact that \( \sigma < 1 \), \( P_{x}/P_{a} \) declines with positive neutral technical change. When \( \lambda_{0} < 0 \), \( P_{x}/P_{a} \) is more likely to decline under this type of technical change if the elasticity of agricultural commodity supply is close to (a large fraction of) that of marketing inputs.

Case 4: \( e_{a} < e_{b}, \sigma < 1, \tau = -(\lambda_{0}/\lambda_{1}) \). It follows from case 3 that \( \Lambda < 0 \) when \( e_{a} < e_{b} \) and \( \sigma < 1 \) if \( \tau < -(\lambda_{0}/\lambda_{1}) \). Since \( \tau \) is always positive, this condition requires that \( \lambda_{0} \) be negative. This condition occurs when \( \eta \) = 0. When \( \sigma = 0 \) it occurs only when the absolute value of \( \eta \) is less than \( k_{d} \). In the limiting case when both \( \sigma \) and \( \eta \) equal 0, the critical value of \( \tau \) is \( 1/(1 + e_{b}k_{d}^{-1}) \). For example, when \( \sigma = \eta = 0, e_{b} = 2, \) and \( k_{d} = 0.5 \), the critical value of \( \tau \) is 0.2. If under these conditions the elasticity of agricultural commodity supply \( (e_{a}) \) is less than 0.2\( e_{a} \), or 0.4, the retail-farm price ratio increases with a neutral increase in factor productivity. In general both extremely limited substitutability between agricultural commodities and marketing inputs and an inelastic demand for the retail product are necessary conditions for the retail-farm price ratio to increase in the presence of neutral technical change.

The effect of \( b \)-saving technical change on the retail-farm price ratio is similarly derived from equations (8) as

\[ \frac{d\ln(P_{x}/P_{a})}{\epsilon} = \frac{(g_{a5} - g_{a4})}{\Delta}, \]

for \( S = (0, 0, 0, 0, \delta, 0)^{\prime} \),

\[ = \sigma k_{a} e_{a} + k_{b} e_{b} - \gamma(\sigma + e_{a}). \]

Since the numerator in equation (15) is normally positive the whole expression is negative. The implication is that technical change that is \( b \)-saving will reduce the retail-farm price ratio.

Technical Change and Factor Shares

Equation (8) can also be used to assess the impact of neutral technical change on the share of revenues imputed to agricultural commodities:

\[ d\ln(k_{a})/\delta = \frac{(g_{a4} - g_{a2} - g_{a5} + g_{a4})}{\Delta}, \]

for \( S = (0, 0, 0, \delta, 0)^{\prime} \),

\[ = \frac{[k_{a}(1 + \eta)(1 - \sigma)(e_{b} - e_{a})]}{\Delta}. \]

The three parenthesized expressions in the numerator may be positive, zero, or negative. If any one is zero, \( a \)'s factor share does not change when neutral technical change occurs. Of the remaining eight possibilities, four imply that \( a \)'s factor share increases and four imply that it decreases with neutral increases in factor productivity.\(^4\) No more specific general statement can be made.

However, if the elasticity of agricultural commodities supply is lower than that of marketing inputs, if the elasticity of substitution between the two factors is less than unity, and if the demand for food is inelastic \( (\eta > -1) \), then neutral increases in factor productivity decreases the farmer’s share of the food dollar.

The effect of \( a \)-biased technical change on the farmer’s share of the food dollar can be derived as

\[ d\ln(k_{a})/\epsilon = \frac{(g_{a5} - g_{a3})}{\Delta}, \]

for \( S = (0, 0, 0, 0, \delta, 0)^{\prime} \),

\[ = \frac{M}{\Delta}, \]

where \( M = \mu_{o} - \mu_{o} \tau. \)

\[ \mu_{o} = -\sigma[\eta + e_{a}(1 - 2k_{a})], \]

and \( \mu_{1} = \sigma e_{b}(\eta + e_{b} + 2k_{a}) \).

Four feasible values of parameter combinations in equation (17) determine the directional impact of \( a \)-biased technical change on the farmer’s share of the food dollar.\(^5\)

---

\(^4\) Since each of the three factors may be either positive or negative, the products of each of the eight possible signed combinations imply a positive or a negative sign for the numerator of equation (16).

\(^5\) It is possible to identify a potential bias in Gardner’s estimate.
Case 1: $\tau > 1$. Since this condition implies that $e_a > e_b$, it follows by substituting $\tau = e_a/e_b$ into the expression for $M$ that $M < 0$ when $\tau > 1$. Therefore, whenever the elasticity of agricultural commodity supply exceeds that of marketing inputs positive $a$-biased technical change increases the farmer’s share of the food dollar.

Case 2: $\mu_0 < 0$, $\tau \leq 1$. Since the numerator $(M)$ in equation (17) is a declining function of $\tau$ ($\mu_1$ is normally positive), $M$ is always negative if $\mu_0 < 0$. This occurs if $k_a < (e_b - \eta)/(2\epsilon_b)$. Thus, ceteris paribus, the smaller the share of agricultural commodities is to begin with, the more likely it is to rise as $a$-biased technical change occurs.

Case 3: $\mu_0 > 0$, $(\mu_0/\mu_1) < 1$, $(\mu_0/\mu_1) < \tau < 1$. Since $M$ is a declining function of $\tau$, $M$ assumes negative values for all $\tau > \mu_0/\mu_1$. When $(\mu_0/\mu_1) < 1$, those values of $\tau$ above $\mu_0/\mu_1$ imply a negative value for $M$ and an increase in $k_a$ resulting from an increase in $\epsilon$. Therefore, agricultural supply elasticities close in value to those of marketing inputs are more likely to be accompanied by increases in the farmer’s share of the food dollar when the positive agricultural commodity biased technical change occurs.

Case 4: $\mu_0 > 0$, $\tau = (\mu_0/\mu_1)$. Following the preceding logic, these conditions imply that $M$ assumes a positive (or zero) value and hence that the farmers share of the food dollar falls (remain constant). Consequently, if the elasticity of agricultural commodity supply is small relative to that of marketing inputs, the farmer’s share of the food dollar is more likely to fall when $a$-biased technical change occurs.

Empirical Applications

The implications of these results for agriculture can be further examined by empirical applications of equations (12), (15), (16), and (17). First, a sensitivity analysis is presented based on various ranges of reasonable parameter values. Then, the theory is applied to explain shifts in the farm product price-farm wage ratio and in farm labor’s relative share in the farm production stage rather than in the marketing stage.

The four equations can be interpreted as elasticities since each is a ratio of logarithmic differentials. Given the precise definitions of $\delta$ and $\epsilon$ in table 1, equation (12) is the elasticity of the retail-farm price ratio with respect to neutral technical change, defined as an equal relative change in the marginal products of both $a$ and $b$. Equation (16) similarly defines the elasticity of the farmer’s share with respect to neutral technical change, while equation (15) can be interpreted as the elasticity of the retail-farm price ratio with respect to $a$-biased technical change defined as the relative change in $a$’s marginal product that leaves output unchanged for the two inputs used prior to the change. Finally, equation (17) is the elasticity of the farmer’s share with respect to $a$-biased technical change. All four elasticities represent percentage changes in variables associated with equilibrium positions before and after technical change.

In the sensitivity analysis it is assumed—as in Gardner’s table 1—that reasonable hypothetical parameter estimates for these equations are $k_a = 0.5$, $\eta = -0.5$, $e_a = 1.0$, $e_b = 2.0$, and $\sigma = 0.5$. (Hereafter these estimates are referred to as the baseline values.) The analysis is completed by computing the value of each of the four equations eighty-four times: twenty-one times in increments of 0.25 over the closed interval $[0,5]$ for each of three parameters $(e_a, e_b, and \sigma)$ and over the closed interval $[-5,0]$ for $\eta$ while all other parameters are held at their baseline values. The results are shown in figures 1 through 4. For example, the plot labeled $e_a$ in figure 1 shows the values of equation (12) when $e_a$ is varied from 0 to 5 and all other parameters are held constant at their baseline values.

Figure 1 shows that over all of the chosen parameter values the retail-farm price ratio declines in the presence of neutral technical change. Over the selected parameter ranges induced changes in the ratio are least sensitive to changes in the elasticity of substitution. As dictated by the theoretical results, the retail-farm price ratio declines when $a$-biased technical change occurs (figure 2). Changes in the elasticity of farm product demand induce virtually no change in the ratio.

Figure 3 summarizes the effects of neutral technical change on the farmer’s share. These calculations illustrate that the direction of the change is not easily predictable. For the baseline parameter values the farmer’s share would decline with neutral technical change. Figure 4 shows that for all hypothesized parameter value combinations the farmer’s share will rise with $a$-biased technical change, even when $e_a = 0$. When $\sigma = 0$ there is no change in the farmer’s share, and it changes very little in response to changes in the product demand elasticity.

The sources of change in the relative share of labor in agriculture can also be analyzed. Lianos determined that technological progress in American agriculture has been capital using. His preferred estimate of the bias $(B)$ of technological progress, defined strictly as the average difference between the logarithmic differential of the marginal product of capital and that of labor, is 0.129. This estimate
Figure 1. Sensitivity of equation (12) to variations in four elasticities

Figure 2. Sensitivity of equation (15) to variations in four elasticities
Figure 3. Sensitivity of equation (16) to variations in four elasticities

Figure 4. Sensitivity of equation (17) to variations in four elasticities
and Lianos' first estimate of 0.294 for the relative share of capital imply a value of \( \epsilon \) equal to 
\(-0.09107.\)\(^6\)

It is of interest to determine the percentage change in the farm product price-farm wage ratio and in the relative share of labor that accompany such a level of biased technical change. The elasticity of labor is available as the inverse of the coefficient on the farm labor variable in Wallace and Hoover. This estimate implies an elasticity of farm labor supply of about 18.87. If estimates of the elasticity of farm product supply \( (e_p) \) of the elasticity of substitution and of relative shares are available, these data in conjunction with the estimate of the labor supply elasticity are adequate to estimate the elasticity of capital supply.\(^7\) Griliches's long-run estimate of \( e_s \) equal to unity is assumed, and Lianos's estimates of \( \sigma = 1.524 \) and \( k_o = 0.294 \) are used. These values imply an elasticity of capital supply of 0.336. All of these values are substituted into equations (15) and (17), which are then multiplied by \(-0.09107\) to determine the two associated relative changes. These calculations are completed for two estimates of the elasticity of farm product demand, \(-0.5\) and \(-0.35\) (see Lianos for the sources of these estimates). The results suggest that Lianos's estimate of \( B \) implies a 3.85% annual increase in the farm product price-farm wage ratio in the first case and a 4.17% annual increase in the second case. Similarly, the relative share of labor decreases 16.87% annually in the first case and 16.69% in the second.

These results obviously imply much larger annual percentage decreases in farm labor's relative share than those predicted by Ferguson's model used by Lianos. The main reason for this is that equation (17) accounts for nonfinite factor supply and product demand elasticities while Lianos' basic

\(^6\) In the notation of this paper \( B = \partial \ln f_o / \partial \ln f_o \), Muth's definition of \( \epsilon \) implies that \( B = -\epsilon(1 + k_o/k_i) \). Consequently, \( B = 0.294 \) implies the value of \( \epsilon \) given in the text, assuming \( k_o = 0.294 \).

\(^7\) This can be accomplished by solving the equation expressing the derived elasticity of product supply for \( e_s \); this equation is given in both Muth and Wiseacre.

\[ \text{References} \]


