REVIEW OF MARKETING AND AGRICULTURAL ECONOMICS
VOL. 47, No. 2 (*August*, 1979)

Interpretation of Cost-Price Ratios

Brenda Jackson*

The usefulness of movement in costs and prices (sometimes termed the "cost-price squeeze") has been challenged by a number of authors. Despite this, a theme which remains common to some recent articles is that a decline in the ratio of prices received to prices paid denotes a situation which must be overcome. A simple model is used to demonstrate why movements in aggregate costs and prices tell us very little about the state of the agricultural sector and, in particular, about farm income. Results of the model are examined in conjunction with actual movements in selected agricultural indicators over the past twenty-five years.

Introduction

For many years, the experience in developed countries has been for the ratio of prices received for agricultural products to prices paid for agricultural inputs to decline. In Australia, formal measurement of cost-price ratios[1] commenced in the early 1950's. The BAE constructed such ratios in order to:

> "enable those interested to trace variations in the purchasing power of prices received by farmers producing specific products, or by the farming community as a whole" [17, p. 149].

Over the years, this phenomena has come to be known as the "cost-price squeeze" and has sometimes been used as an indicator of problems in the agricultural sector, particularly those related to declining farm income and of a need for policy measures designed to reverse adverse trends in costs and prices. For example, Miller [14, p. 29] states that:

> "In view of the likely continuation of accelerated cost-price pressures on the farm sector, the bulk of the article is devoted to a consideration of appropriate policy responses."

While, in some cases authors have warned against a direct translation of movements in costs and prices into movements in net farm income, there has nonetheless been a tendency to concentrate on measures which can be used to offset the effects of a cost-price squeeze (*e.g.*, [2], [7], [8], [12] and [14]). This usually involves two implicit assumptions. First, that the existence of a cost-price squeeze indicates that the incomes of individual farmers are declining. Second, that the objective of maintaining acceptable incomes in the agricultural sector can be effectively met by policies aimed at the cost-price squeeze.

---

* The author was formerly with the Industries Assistance Commission, and is currently employed by the Australian Wool Corporation. An earlier version of this paper was presented at the 23rd Annual Conference of the Australian Agricultural Economics Society, Canberra, 6-8th February, 1979. The author would like to thank, without implication, Andrew Stoeckel for his assistance with the model, and Sandy Cuthbertson, John Zeitsch and referees for helpful comments. The views expressed in this paper do not necessarily reflect those of the Industries Assistance Commission.

[1] These ratios are of the Laspeyres type using fixed base period weights in an attempt to isolate price movements. Full details of the method used in Australia to construct these ratios are given in BAE [1], O'Donohue and Cox [15] and Saxon [16], [17] and [18].

A theme common to these articles is that a decline in the ratio of prices received to prices paid denotes a situation which requires attention. In nearly every case, authors offer solutions such as productivity improvements, price agreements, or changes in tariffs. A point worth noting, however, is that these endeavours are not only appropriate when there is a cost-price squeeze. Farmers should be aware of the gains from productivity increases, lowering of assistance levels on imported inputs, etc. Indeed, investment in new techniques is probably more appropriate and likely when prices are improving relative to costs and finance is readily available.

The usefulness of movements in aggregate costs and prices as indicators of problems in the agricultural sector has been challenged by a number of authors ([3], [5], [10] and [12]). Even so, they continue to be widely quoted, often with the justification that they are an easy reference point. This suggests, however, that previous criticisms were either not valid or not convicing enough. This paper takes as a starting point the proposition suggested by Hillman in relation to the cost-price squeeze. That is:

> "it is not that it is false but that it discloses a partial truth, a truth, that is, as to what we want to believe." [10, p. 638].

The proposition examined in this paper is that movements in costs and prices offer limited information about individual farm income levels. Additional information required before conclusions can be drawn about the impact on farm income would include:

(i) whether movements in costs, prices or some combination of both were responsible for adverse trends in cost-price ratios;

(ii) the cause(s) of the initial shifts in costs and/or prices;

(iii) possible responses to changes in cost-price ratios, *i.e.*, changes in the factor-product mix, product mix, etc.

The contribution of this paper is the development of a simple model to examine the role of a range of external demand and supply factors on the terms of trade in agriculture (*i.e.*, the ratio of prices received to prices paid) and on net farm income. In particular, the conditions under which net farm income and terms of trade move in the same direction, opposite directions or either of these cases depending on the slope of the demand and supply curves are identified.

Framework for Analysis

The agricultural sector is assumed to produce one product and use two inputs (labour and capital). For simplicity, a Cobb-Douglas production function with constant returns to scale is assumed.[2] The collective actions of farmers are assumed to influence the prices they receive for their output and pay for inputs. The terms of trade for agriculture are therefore endogenous

[2] Brandow [4] discussed some of the limitations associated with the use of a Cobb-Douglas production function while Gardner [6] used a more general form for the production function (with Cobb-Douglas as a special case).

to the model, even though exogenous changes may have initially moved the terms of trade one way or the other.[3] In the model, net farm income is defined as:

$$F = PY - WL \tag{1}$$

where F = net farm income,
P = output price,
Y = output,
W = input price (wages), and
L = purchased inputs (labour).

Alternatively, net farm income can be expressed as the return to the farmer's capital, *i.e.*,

$$F = RK \tag{1a}$$

where R = interest rate, and
K = capital inputs.

Demand for farm output is assumed to be of the form

$$Y = Z_1 P^{-\sigma} \tag{2}$$

where Z_1 = exogenous shift factor, and
σ = price elasticity of demand.

The exogenous shift factor, Z_1, could be taken to represent shifts in income, changes in tastes, greater access to overseas markets through the negotiation of international agreements, etc.

Minimizing the cost of producing a prescribed level of output, subject to a constant returns to scale Cobb-Douglas production function,[4] yields the following demand equations for labour and capital.[5]

$$L = Y/\beta(W/\alpha)^{\alpha-1}\,[R/(1-\alpha)]^{1-\alpha} \tag{3}$$

$$K = Y/\beta(W/\alpha)^{\alpha}\,[R/(1-\alpha)]^{-\alpha} \tag{4}$$

where β = exogenous technological change parameter, and
$\alpha,\ 1-\alpha$ = partial elasticities of output with respect to labour and capital.

The parameter β could also be interpreted as representing seasonal factors, *e.g.*, drought, good rainfall, etc.

Assume a supply of labour function of the following form:

$$L = Z_2 W^{\rho} \tag{5}$$

where Z_2 = exogenous shift factor, and
ρ = price elasticity of supply of labour.

---

[3] Endogeneity of the terms of trade was assumed in order to make the model more general; since it is likely that collectively farmers are at least partially responsible for the prices they receive and pay [see 13, p. 46]. The more restrictive case where the terms of trade are exogenous is briefly discussed later in the paper.

[4] $Y = \beta L^{\alpha} K^{1-\alpha}$ where $\alpha,\ 1-\alpha$ are the partial elasticities of output with respect to labour and capital ($0 < \alpha < 1$).

[5] See for example, Henderson and Quandt [9, p. 65].

Exogenous shift factors affecting the supply of labour to agriculture are represented by Z_2, *e.g.*, a decrease in standard working hours for sectors other than agriculture.

Assume a constant supply of capital:

$$K = \text{constant} \tag{6}$$

Finally, from the assumptions of perfect competition and profit maximisation, the relation that output price equals marginal cost is derived.

$$P = 1/\beta\{[W/\alpha]^{\alpha}\,[R/(1-\alpha)]^{1-\alpha}\} \tag{7}$$

The above system of seven equations in seven variables was expressed in percentage change form as follows:

$$\hat{F} = \hat{R} + \hat{K} \tag{1a)'}$$

$$\hat{Y} = \hat{Z}_1 - \sigma\hat{P} \tag{2)'}$$

$$\hat{L} = \hat{Y} - \hat{\beta} + (\alpha - 1)\hat{W} + (1 - \alpha)\hat{R} \tag{3)'}$$

$$\hat{K} = \hat{Y} - \hat{\beta} + \alpha\hat{W} - \alpha\hat{R} \tag{4)'}$$

$$\hat{L} = \hat{Z}_2 + \rho\hat{W} \tag{5)'}$$

$$\hat{K} = 0 \tag{6)'}$$

$$\hat{P} = \alpha\hat{W} + (1 - \alpha)\hat{R} - \hat{\beta} \tag{7)'}$$

where a ^ over a variable denotes percentage changes, *e.g.*, $\hat{F} = \delta F/F$.

Solution of this system for $\hat{F}$ (the percentage change in net income) yields the following expression:

$$\hat{F} = \varphi_1\hat{Z}_1 + \varphi_2\hat{\beta} + \varphi_3\hat{Z}_2 \tag{8}$$

where
$$\varphi_1 = (\rho + 1)/[\sigma(\rho + 1) - \alpha(\sigma - 1)\rho]$$
$$\varphi_2 = [(\rho + 1)(\sigma - 1)]/[\sigma(\rho + 1) - \alpha(\sigma - 1)\rho]$$
$$\varphi_3 = [\alpha(\sigma - 1)]/[\sigma(\rho + 1) - \alpha(\sigma - 1)\rho].$$

In this system, the terms of trade are expressed as

$$\hat{TOT} = \hat{P} - W \tag{9}$$

where $\hat{TOT}$ = percentage change in the terms of trade and a cost-price squeeze is denoted by a decline in the terms of trade.

Using equations (1a)', (6)' and (8), it is possible to substitute back into the initial equations to derive the following expression for $\hat{TOT}$:

$$\hat{TOT} = \psi_1\hat{Z}_1 - \psi_2\hat{\beta} + \psi_3\hat{Z}_2 \tag{10}$$

where
$$\psi_1 = [\rho(1 - \alpha)]/[\sigma(\rho + 1) - \alpha(\sigma - 1)\rho]$$
$$\psi_2 = (\rho + \sigma)/[\sigma(\rho + 1) - \alpha(\sigma - 1)\rho]$$
$$\psi_3 = [\sigma(1 - \alpha)]/[\sigma(\rho + 1) - \alpha(\sigma - 1)\rho]$$

That is, both net farm income (8) and the terms of trade (10) can be expressed as functions of the three exogenous shift factors (Z_1, β and Z_2). The coefficients of the shift factors depend on the values of the elasticities (σ, α and ρ). Equations (8) and (10) permit identification of the situations in which the existence of a decline in the cost-price ratio *is accompanied* by a decline in net farm income and *is not accompanied* by a decline in net farm income. Cases in which it is not clear whether or not net farm income and terms of trade move together or in opposite directions are also identified.

The impact of changes in the exogenous variables on the terms of trade and net farm income was examined for a variety of situations.[6] The resultant effect on net farm income and terms of trade is dependent on the sign and magnitude of the coefficients (φ_i, ψ_i) which in turn depends on the elasticity values (σ, α and ρ). The coefficients of each exogenous variable for both equations were evaluated over a range of parameter values[7] and the results are summarized in Table 1.[8] Given a specified cause of movement in terms of trade, the results allows examination of the effect on net farm income.

Viewing the existence of a cost-price squeeze in isolation, therefore, offers only limited information. It is essential to determine the cause and effect of a cost-price squeeze before any conclusions regarding its impact on net farm income can be made.

Table 1 shows that a cost-price squeeze will occur when either:

(i) demand for output falls, *e.g.*, tastes alter away from agricultural products and hence Z_1 declines;

(ii) supply of output increases, *e.g.*, increased productivity due to technological changes and hence β increases; or

(iii) a decline in the supply of labour to agriculture occurs, *e.g.*, due to the introduction of shorter working hours in other sectors making agriculture less attractive and hence Z_2 declines.

The resultant effect on net farm income of movements in each of the above exogenous factors is less obvious. Although terms of trade and income move in the same direction as a result of shifts in demand (Z_1), the situation is more complicated for shifts in the two supply shift factors (β and Z_2).

Examination of the results for β and Z_2 indicates that terms of trade can deteriorate and yet income can decrease, remain the same or even increase, depending on the slope of the demand curve (*i.e.*, the value of the price elasticity of demand, σ). If a shift in the exogenous technology variable β takes place, an elastic demand for output curve is necessary for terms of trade and net farm income to move in the same direction. Alternatively, where a change in the labour supply shift factor Z_2 takes place, an inelastic demand

[6] A similar approach was used by Gardner [6] in an article about changes in the ratio of retail to farm prices.

[7] The following ranges of parameter values, $0 < \sigma < 4$, $0 < \alpha < 1$ and $0 < \rho < 2$ were chosen on the basis of prior expectations in order to reflect likely actual elasticity values.

[8] The contribution of each exogenous factor was examined holding the remaining two factors constant.

Table 1: *Summary of Results*

Exogenous Factor	Direction of Movement in				Extent of Movement in $T\hat{O}T$ Relative to $\hat{F}$ (at identical parameter values)
	Exogenous Factor	$T\hat{O}T$	$\hat{F}$	$T\hat{O}T$ compared to $\hat{F}$	
Z_1	Increase	Increase	Increase	Same	$\hat{F} > T\hat{O}T$
	Decrease	Decrease	Decrease	Same	$\hat{F} > T\hat{O}T$
β	Increase	Decrease	Increase for $\sigma > 1$ No change for $\sigma = 1$ Decrease for $\sigma < 1$	Depends on value of σ	Both cases depending on values of σ and α
	Decrease	Increase	Increase for $\sigma < 1$ No change for $\sigma = 1$ Decrease for $\sigma > 1$	Depends on value of σ	Both cases depending on values of σ and α
Z_2	Increase	Increase	Increase for $\sigma > 1$ No change for $\sigma = 1$ Decrease for $\sigma < 1$	Depends on value of σ	Both cases depending on values of σ and α
	Decrease	Decrease	Increase for $\sigma < 1$ No change for $\sigma = 1$ Decrease for $\sigma > 1$	Depends on value of σ	Both cases depending on values of σ and α

curve is necessary for movements in the same direction to occur.[9] Thus, the existence of declining terms of trade is not a sufficient condition for a decline in net farm income to occur. Similarly, a decline in net farm income can take place even though terms of trade are improving (e.g., due to an increase in Z_2). Hence, a decline in the terms of trade is not a necessary condition for a decline in net farm income to occur.

Another feature of the results can be seen from a comparison of the relative magnitudes of shifts in the terms of trade and net farm income. Movements in net farm income will exceed those for terms of trade when the movements are generated by an exogenous demand shift factor such as greater access to overseas markets. However, in cases where movements are generated by an exogenous supply shift, i.e., technology or labour supply factors, there is no strict relationship between the magnitude of shifts in net farm income and terms of trade.

If the assumption that farmers collectively influence the prices they receive and pay is relaxed, the model is simplified as follows. Price terms in the equations for supply of labour, output and net farm income will be exogenous and shifts in the remaining variables in each equation will have no impact on prices. Consequently, the impact of adverse shifts in any of the exogenous factors would be transmitted directly to net farm income without the possibility of any compensating movements in terms of trade. However, it is possible for adverse movements in terms of trade to take place without a corresponding decline in net farm income, since the aggregate production and supply of labour functions may vary in a manner which will offset the initial movement in terms of trade.

In the case of any individual farmer, who is a price taker in both the product and factor markets, changes in the ratio of prices received to prices paid are not appropriate indicators of movements in farm income for several reasons. Farm income equals revenues minus cost for all output produced and factors used. Using the previous notation

$$F = \sum_{i=1}^{n} P_i Y_i - \sum_{j=1}^{m} W_j L_j \tag{11}$$

Relative factor and product prices, therefore have only a partial role in income determination.[10] Movements in levels of output and factors employed can offset or reinforce movements in prices. Resultant effects on income cannot be determined from price movements alone. The ability of farmers to substitute between a wide range of factors and products severely limits the usefulness of information available from base period weighted indexes such as those used to form cost-price ratios. In addition, not only can farmers substitute factors and products, but also since individual farmers will experience different price and cost conditions and have different product and factor mixes,

[9] Stoeckel [19, p. 19] notes that previous "studies have shown that the elasticity of demand for Australian exports is less than unity, which is unbelievably low".

[10] In this context, a cost-price squeeze has traditionally been indicated by a decline in a cost-price ratio of the form

$$\Sigma(P_{it} Y_{it}) / \Sigma(W_{jt} L_{jb})$$

where t = current period, and
b = base period.

the information available from the terms of trade calculated at an aggregate level will be limited.[11] Finally, it should be remembered that prices are merely signals to indicate that changes in the *demand and/or supply* conditions operating in the relevant markets have occurred. It is necessary to examine the underlying causes of such change before the implications for individual farm income can be identified.[12]

Trends in the Terms of Trade and Real Farm Income

This section examines the results of the model in the light of Australian data from the past twenty-five years. Movements in terms of trade, real farm income and the contribution of agriculture to gross domestic product (GDP)[13] over the period 1953–54 to 1975–76 are shown in Figure 1.

On several occasions, a deterioration in terms of trade did not coincide with a decline in farm income. In 1958–59, the terms of trade were still falling, while income and the contribution of agriculture of GDP had picked up again. Similarly in 1966–67, terms of trade declined yet income and the contribution of the agricultural sector increased.

The other feature of interest is the difference in magnitude of fluctuations in the terms of trade relative to income. Over the entire period, farm income and the contribution of agriculture to GDP have fluctuated more widely than the terms of trade (Figure 1). This is consistent with the preceding model. The most obvious example of this situation occurred in 1973–74. Terms of trade increased from 1971–72 to 1972–73 but then remained stationary over the next twelve months. Farm income and the contribution of agriculture to GDP, on the other hand, increased substantially in 1973–74.

Conclusions

In view of the apparently limited impact of cautions issued to users of the cost-price squeeze notion, the author has attempted to explain why movements in costs and prices in isolation tell us very little about the state of the agricultural sector, in particular farm income, or the need for policy measures.

A simple model was developed to enable examination of the relationship between movements in the terms of trade and net farm income in the agricultural sector. The importance of factors other than relative costs in influencing net farm income was highlighted. The existence of a cost-price squeeze was shown to be neither a necessary nor sufficient condition for a decline in net farm income to occur. Differences in the relative magnitude of movements in net farm income and terms of trade resulting from exogenous shocks were also noted. The importance of examining the causes of, and possible responses to declining terms of trade, before any conclusions regarding the effect on net farm income can be reached, was illustrated.

---

[11] The limitations associated with the use of Laspeyres indices are not considered in this paper. Some of the limitations are discussed in [1] and [15].

[12] Further, Houck [11, p. 208] notes some reasons why even aggregate income is not necessarily a good guide to individual farm income.

[13] The contribution of agriculture to GDP is included to give an indication of agriculture's relative position in the economy. The existence of a cost-price squeeze is sometimes quoted as being partially responsible for the decline in agriculture's relative position in the economy.

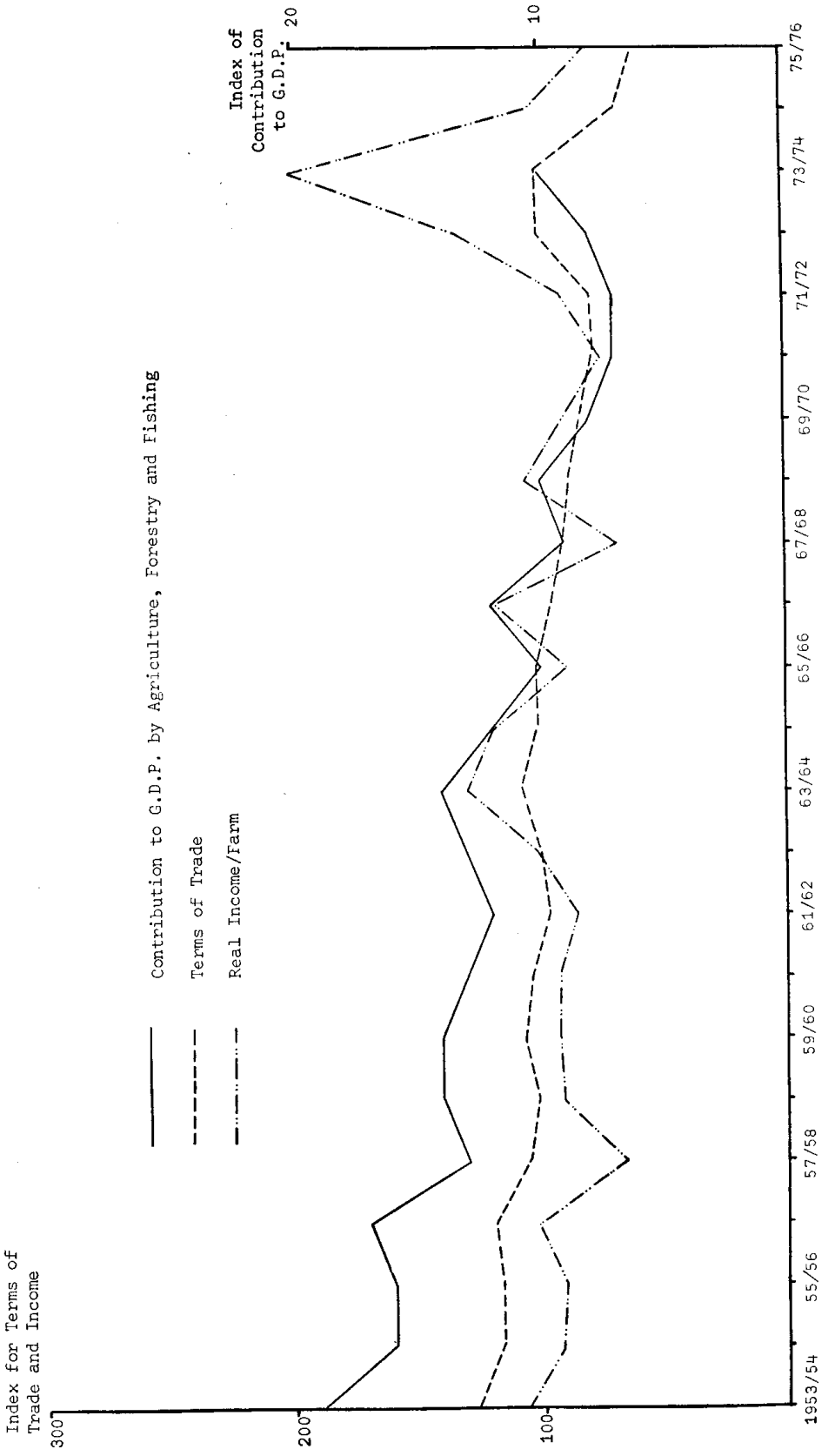

Figure 1: *Selected Agricultural Sector Indicators* 1953–54 – 1975–76

Even in the case of an individual farmer, for whom the terms of trade are exogenous, knowledge of the existence of declining terms of trade in agriculture offers little information in relation to the effect on farm income. Individual farm income will only decline as a result of adverse movements in relative product and factor prices if the quantities of factors used and output produced do not alter, or alter in a manner which either fails to offset or reinforces the initial adverse movements in prices. Since these outcomes are only a subset of the possible outcomes, it is misleading and inaccurate to use the cost-price squeeze as an indicator of income problems for farmers.

Historical data were used to pin-point occasions when the terms of trade and farm income moved in opposite directions and the differences in the extent of relative movements in terms of trade and farm income which took place.

References

[1] Bureau of Agricultural Economics, "Index of Prices Received and Paid by Farmers in Australia: Rebasing and General Revision", *Quarterly Review Agric. Econ.*, Vol. XXII, No. 2, April, 1969.

[2] *National Agricultural Outlook Conference* 1977—*Keynote Addresses*, Documents and Discussion, Vol. 1, A.G.P.S., Canberra.

[3] Boulding, K. E., "Economics as a Moral Science", *The American Economic Review*, Vol. LIX, No. 1, March, 1969.

[4] Brandow, G. E., "Demand for Factors and Supply of Output in a Perfectly Competitive Industry", *American J. Agric. Econ.*, Vol. 44, No. 3, August, 1962.

[5] Campbell, K. O., *Agricultural Marketing and Prices*, Cheshire, Melbourne, 1973.

[6] Gardner, B. L., "The Farm-Retail Price Spread in a Competitive Food Industry", *American J. Agric. Econ.*, Vol. 57, No. 3, August, 1975.

[7] Glau, T. E., "The Cost-Price Squeeze on Australian Farm Income", *Aust. J. Agric. Econ.*, Vol. 15, No. 1, April, 1971.

[8] Gruen, F. H., "Australian Agriculture and the Cost-Price Squeeze", *Aust. J. Agric. Econ.*, Vol. 6, No. 1, September, 1962.

[9] Henderson, J. M. and Quandt, R. E., *Microeconomic Theory*, McGraw-Hill, 1971.

[10] Hillman, J. S., "On Returning from Our Agricultural Babel", *American J. Agric. Econ.*, Vol. 52, No. 5, December, 1970.

[11] Houck, J. P., "Some Aspects of Income Stabilization for Primary Producers", *Aust. J. Agric. Econ.*, Vol. 17, No. 3, December, 1973.

[12] Lloyd, A. G., "Some Current Policy Issues", *Aust. J. Agric. Econ.*, Vol. 14, No. 2, December, 1970.

[13] Mauldon, R. G., and Schapper, H. P., *Australian Farmers Under Stress in Prosperity and Recession*, Univ. of W.A. Press, 1974.

[14] Miller, G., "Intersectoral Competition and Prosperity: Some Policy Issues", *Aust. Econ. Review*, 4th Quarter, 1976.

[15] O'Donohue, R. F. and Cox, A. E., "The Measurement and Interpretation of Trends in the Cost-Price Situation of the Farm Sector", *Quarterly Review Agric. Econ.*, Vol. XIV, No. 3, April, 1961.

[16] Saxon, E. A., "Measurement and Movement of Prices Paid and Received by Farmers", *Quarterly Review Agric. Econ.*, Vol. IV, No. 3, July, 1951.

[17] Saxon E. A., "Movement in Prices Received and Paid by Farmers", *Quarterly Review Agric. Econ.*, Vol. V, No. 4, October, 1952.

[18] Saxon, E. A., "The Measurement and Movement in Prices Received and Paid by Primary Producers", *Quarterly Review Agric. Econ.*, Vol. VII, No. 3, July, 1954.

[19] Stoeckel, A., "Some General Equilibrium Effects of Mining Growth on the Economy", *Aust. J. Agric. Econ.*, Vol. 23, No. 1, April, 1979.