ELASTICITY OF SUPPLY AND THE INCENTIVE FOR COLLUSIVE BUYING

R. R. PIGGOTT*

Wollongong University College

A model is developed to show how changes in the elasticity of the supply function at the farm level offset increased levels of buyer (processor) concentration such that given percentage increases in demand by large buyers result in the same, or smaller, percentage price changes than do increases in demand on the part of small buyers. Since the incentive for collusive buying is a function of the potential price increases which follow demand increases, there may be little incentive for buyers to collude even if they are highly concentrated.

In a research report on co-operative bargaining in grower-processor markets for fruits and vegetables, Helmberger and Hoos emphasize the importance of elasticity of supply at the farm level as a relevant dimension of market structure when gauging the effects of buyer concentration.[1] They claim that:

Greater elasticity in the supply function tends to decrease the difference between average and marginal resource cost and facilitates independent conduct in the sense that output variations on the part of any one firm will tend to have a correspondingly smaller impact on prices.[2]

The authors' conclusions are intuitively plausible: the incentive for collusive buying of raw material will be smaller, the smaller the potential increases in raw material prices which would result from increases in processors' demand for inputs.[3] Potential price increases will be smaller, the more elastic is supply at the farm level.

It follows that elasticity of supply at the farm level is a force which can offset the level of buyer concentration in determining the market out-

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[1] Helmberger, P. G., and Hoos, S. *Co-operative Bargaining in Agriculture: Grower-Processor Markets for Fruits and Vegetables.* University of California Agricultural Publications, Berkeley, 1965, pp. 129-138. The authors found that, despite high levels of concentration among fruit and vegetable processors, '. . . the elasticity of supply for vegetables, the existence of fresh market outlets for certain fruits, the low barriers to entry, and the extent of grower integration into processing through co-operatives mean little significance should be attached to the high levels of concentration.' (p. 183).

[2] *Ibid.*, p. 129. They define *average resource cost* as 'the total financial outlay on some input divided by the quantity of input purchased' (p. 196), and *marginal resource cost* as 'the increment in the total outlays on an input associated with a unit increase in the firm's purchases of that input' (p. 199).

In the present context, the 'resource' is a processing fruit or vegetable, the 'firm' is the processor, and the 'prices' are resource prices.

[3] Helmberger and Hoos point out that concentration is more meaningfully appraised if the elasticity of demand facing the processing industry is known (*Ibid.*, p. 130). If the demand for the output of the processing industry is highly inelastic, then processors may be prepared to accept substantial increases in the price of raw materials, rather than colluding in order to keep raw material prices down. In the present article, it has been necessary to abstract away from this additional consideration.

come. If supply is highly elastic, there may be little incentive toward collusive buying even in the presence of marked buyer concentration. Conversely, if supply is highly inelastic, there may be an incentive toward collusive buying even in the absence of marked buyer concentration.

Helmberger and Hoos define the relationship between a processor's share of available raw material (S), elasticity of raw material supply (E), and the impact on price (which the present author denotes by $\Delta P/Pa$) of a proportionate increase (C) in the processor's demand for the raw material as:[4]

$$\Delta P/Pa = 2CS/E(2 + CS) \tag{1}$$

They summarize their results in a table which is reproduced below (Table 1), and conclude, for example, that:

> If price elasticity of market supply equals 3 . . . a firm accounting for 60 per cent of the total purchases would cause a smaller increase in price by expanding the level of input than would a firm accounting for only 20 per cent of the total purchases in a situation where $E = 1$.[5]

TABLE 1

Percentage Changes in Price Associated With Various Price Elasticities of Market Supply and Processor's Share of Market Output (Assuming that Proportional Change in Amount Demanded by Processors Equals 0·1)

Price elasticity of market supply (E)	Processor's share of market output (S)			
	·60	·40	·20	·10
	Percentage change in price			
1	5·8	3·9	2·0	1·0
2	2·9	2·0	1·0	0·5
3	1·9	1·3	0·7	0·3
5	1·2	0·8	0·4	0·2

Source: Helmberger and Hoos, *Co-operative Bargaining in Agriculture*, p. 131.

The authors have taken a step toward quantifying an important aspect of market behaviour. Their analysis is, of course, relevant to other markets beside grower-processor markets for fruits and vegetables. It seems important, therefore, to extend the analysis to allow for a rigorous definition of the relationship between the variables. Such an extension is offered in the remainder of this paper.

[4] ΔP denotes the difference between the original and new prices, and Pa the average of the two prices.
The value of S serves as a measure of the degree of buyer concentration.
Equation (1) may be derived from one of the arc elasticity formulae:

$$E = \{(Q_2 - Q_1)/0{\cdot}5(Q_2 + Q_1)\}/\{(P_2 - P_1)/0{\cdot}5(P_2 + P_1)\},$$

where the subscripts 1 and 2 identify original and new values respectively.
Replacing the expression for the price change by $\Delta P/Pa$ and substituting $(Q_1 + CSQ_1)$ for Q_2,

$$\begin{aligned} E &= \{(Q_1 + CSQ_1 - Q_1)/0{\cdot}5(Q_1 + CSQ_1 + Q_1)\}/\{\Delta P/Pa\} \\ &= \{2Q_1(1 + CS - 1)/Q_1(1 + CS + 1)\}/\{\Delta P/Pa\} \\ &= \{(2CS)/(2 + CS)\}/\{\Delta P/Pa\} \end{aligned}$$

Thus $\Delta P/Pa = 2CS/E(2 + CS)$

[5] *Ibid.*, p. 130.

The aim is to highlight elasticity of supply as an 'offsetting' or 'compensating' influence. This is achieved diagrammatically in Figure 1, which uses a logarithmic scale. Reference to the figure shows that the same percentage price change ($P_2 - P_1$) results from either: (i) an increase in demand of, say, C per cent on the part of a relatively small (in terms of S) processor which shifts total demand from D_1 to D_2 when supply is given by S_2; or (ii) an increase in demand of C per cent on the part of a relatively large processor which shifts total demand from D_1 to D_3 when supply is given by S_1, where S_2 is less elastic than S_1. That is, a more elastic supply response compensates for the greater market share such that the increases in demand result in the same percentage price change.

One can conceive of a map of equal price change contours, where each contour joins various combinations of E and S which yield the same percentage change (k) in the price of the raw material following a given increase in demand by processors of C per cent. Selection of various values of k results in a map of contours. Our formulation of the relationship between the variables becomes analogous to that used in production economics to show how the output of one good must be changed

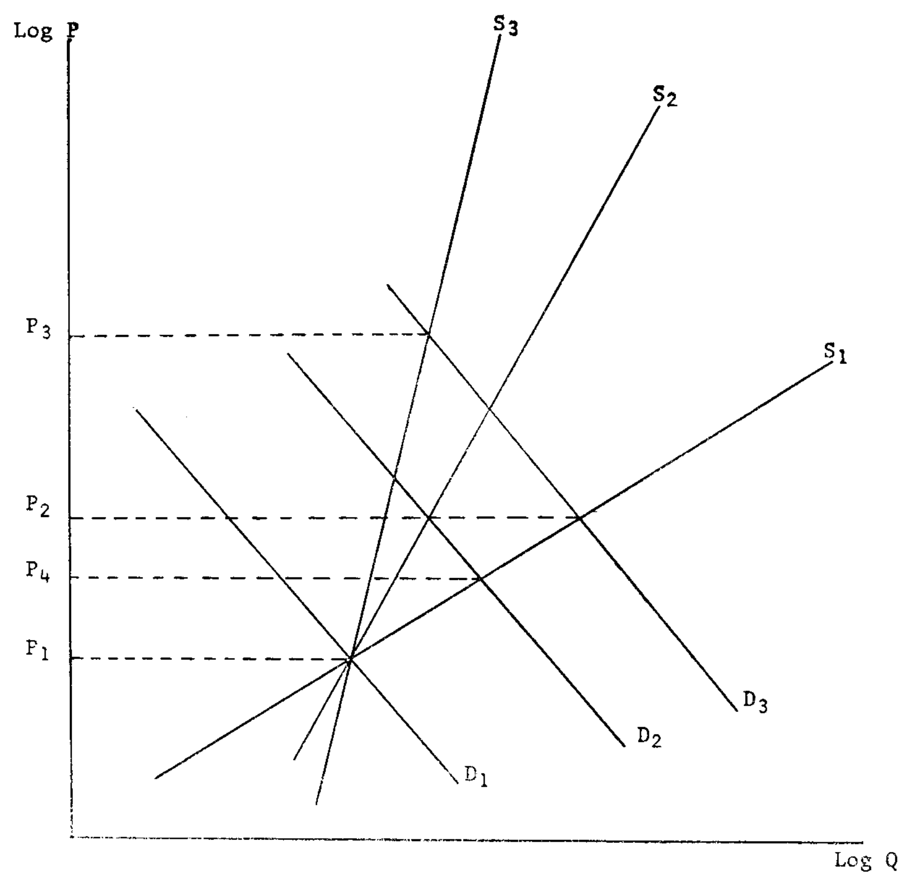

FIG. 1—Various price changes resulting from different demand shifts coinciding with supply curves of differing elasticities (Vertical and horizontal distances reflect *percentage changes* in price and quantity respectively).

if output of another is changed when total resources are fixed in supply (production-possibility contours).

In order to derive a single equal price change contour, equation (1) is rearranged such that E becomes the dependent variable. That is,

$$E = 2CS/k(2 + CS), \tag{2}$$

where $k = \Delta P/Pa$ and is constant at selected levels.

Equation (2) allows the construction of Table 2 and Figure 2, which show those values of E which, when combined with various values of S (10 through 100 per cent), are consistent with various percentage price changes (5 through 20 per cent), when C is assumed constant at 10 per cent (i.e., it is assumed processors increase their demand for raw material by 10 per cent).

A word of caution is necessary in relation to the interpretation of 'percentage price change'. There is a simple relationship between $\Delta P/Pa$ (change in price divided by the average of the original and new prices) and the orthodox expression for a percentage price change, $\Delta P/P_1$ (change in price divided by the original price). By definition

$$Pa = P_1 + 0{\cdot}5\Delta P$$

and $\quad \Delta P/Pa = \Delta P/(P_1 + 0{\cdot}5\Delta P)$;

(3) i.e. $\quad \Delta P/Pa = 1/(P_1/\Delta P + 0{\cdot}5)$.

The percentage price changes shown in Table 2 and Figure 2 are to be interpreted as $\Delta P/P_1$. In calculating the associated values of E, these percentages were first transformed via equation (3) into equivalent $\Delta P/Pa$ values before substitution into equation (2). In Figure 2, contours have been labelled k' (rather than k) since they represent $\Delta P/P_1$ (rather than $\Delta P/Pa$).

The marginal rate of compensation of E for S (M.R.C. of $E \rightarrow S$) is defined as the increase in E which is needed to offset a given increase in S such that C per cent increases in demand by processors are consistent with a given percentage change in the price of the raw material. Alge-

TABLE 2

Combinations of Market Shares (S) and Elasticity of Supply which Would Result in Various Percentage Price Changes (k') if Processors Increased Their Demand by 10 percent (C = 0·10)

S (%)	$k'^{(a)} =$ 5	10	15	20
10	0·204	0·104	0·071	0·055
20	0·391	0·200	0·137	0·105
30	0·606	0·310	0·212	0·163
40	0·804	0·412	0·281	0·216
50	1·000	0·512	0·350	0·268
60	1·194	0·612	0·417	0·320
70	1·386	0·710	0·485	0·372
80	1·577	0·808	0·551	0·423
90	1·765	0·904	0·617	0·474
100	1·952	1·000	0·683	0·524

(a) Values of k corresponding to k' values of 5, 10, 15 and 20 percent are 4·88, 9·52, 13·95 and 18·18 respectively.

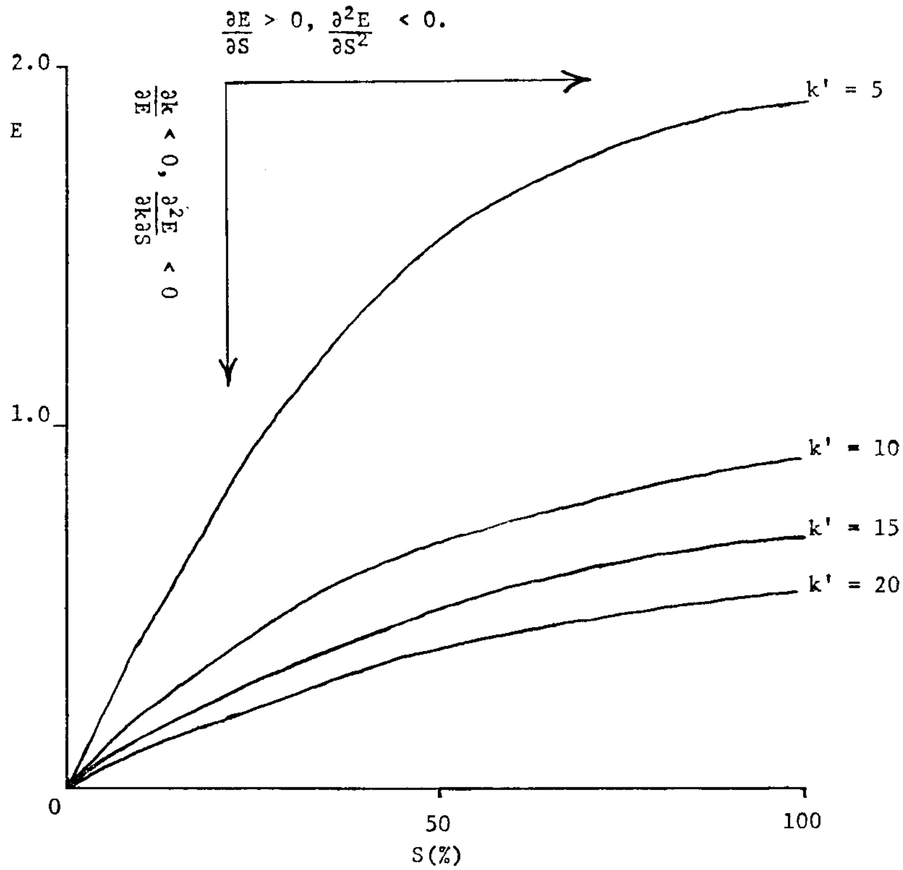

FIG. 2—Combinations of elasticity of supply (E) and raw material shares (S) which result in various percentage price changes (k'), assuming proportional increases in demand by processors of 10 per cent.

braically, the M.R.C. of $E \to S$ is given by the slope of the equal price change contours. That is,[6]

$$\text{M.R.C. of } E \to S = \frac{\partial E}{\partial S} = \frac{-\partial k}{\partial S} \Big/ \frac{\partial k}{\partial E} \; .$$

The relationship between the variables can now be defined as follows:

(i) For a given value of price elasticity of supply, as a processor's share of the available raw material increases, so will the percentage increase in price caused by a C per cent increase in that processor's demand for raw material. This is evidenced by the fact that $\frac{\partial k}{\partial S} > 0$, and it is readily observed from Figures 1 and 2.

(ii) For a given level of a processor's share of the available raw material, the less elastic is supply, the greater the percentage increase in price caused by a C per cent increase in that processor's demand for

[6] This expression is equivalent to the expression for the marginal rate of transformation of product E for product S when resources (k) are fixed.

raw material. This is evidenced by the fact that $\frac{\partial k}{\partial E} < 0$. It is reflected in Figure 2 which shows an inverse relationship between E and k for a given level of S. Reference to Figure 1 reveals that the less elastic is the supply function, the greater the change in price caused by a demand increase.

This result means, of course, that a C per cent increase in demand on the part of a relatively small processor can cause an even greater percentage price increase than the same demand increase on the part of a relatively large processor, *provided* a less elastic supply response compensates for the smaller market share. This can be seen in Figure 1 by comparing the demand increase from D_1 to D_2 when S_3 is the relevant supply curve, with the demand increase from D_1 to D_3 when S_1 is the relevant supply curve. Reference to Table 2 and Figure 2 shows that an increase in demand of 10 per cent on the part of a processor originally purchasing only 10 per cent of the available raw material when E is 0·1 will cause a greater percentage price increase than a 10 per cent increase on the part of a processor originally purchasing 50 per cent of the raw material when E is 1·0.

(iii) The M.R.C. of $E \rightarrow S$ decreases as S increases. This is reflected in the concavity of contours (slightly exaggerated in Figure 2) toward the S axis and is evidenced by the fact that $\frac{\partial^2 E}{\partial S^2} < 0$.

The reason for this result is arithmetic rather than economic. From the arc elasticity formula,

$$(4) \qquad E = (\Delta Q/\Delta P)(Pa/Qa),$$

where ΔQ is the difference between the original and new quantities and Qa is their average. In the present context, ΔQ is given by CSQ_1. Thus, substituting into equation (4),

$$\begin{aligned} E &= (CSQ_1/\Delta P)(Pa/Qa) \\ &= (C/k)(Q_1S/Qa), \end{aligned}$$

where $k = \Delta P/Pa$. The fraction (C/k) is a constant. For small values of S, the C per cent increase in demand will result in small absolute changes in quantity and thus the differences between Qa and Q_1 (original quantity) will be small. The contours appear almost linear.[7] As S increases, however, the differences between Q_1 and Qa become larger and the contours become concave to the S axis.

(iv) For a given level of S, the M.R.C. of $E \rightarrow S$ increases as k decreases. This is evidenced by the fact that $\frac{\partial^2 E}{\partial k \partial S} < 0$. In Figure 2, this result is reflected in the increasing steepness of contours as k decreases, assuming S constant. Reference to Figure 1 will reveal the economic explanation of this result. Consider the shift in demand from D_1 to D_2 collowing a C per cent increase in demand on the part of a relatively small processor. If initially the supply curve for the raw material is relatively inelastic (S_3), the resulting percentage price change is $P_3 - P_1$. It will be observed that the greater is the diff-

[7] If ΔQ had been related to Q_1 rather than Qa, the contours would have been linear.

ference between the magnitude of this price change and the magnitude of any other price change (say $P_2 - P_1$ or $P_4 - P_1$) caused by the demand shift, the greater must be the change in the elasticity of the supply function. For example, the difference between the price changes $P_3 - P_1$ and $P_4 - P_1$ is greater than the difference between $P_3 - P_1$ and $P_2 - P_1$, and the difference in elasticities between S_3 and S_1 is greater than the difference in elasticities between S_3 and S_2.

The conclusion to be drawn from the analysis is that we should dispel *a priori* associations between the level of buyer concentration and the incentive toward collusive buying. It might be assumed that because buying is highly concentrated, there will be an incentive for buyers to collude in order to keep raw material prices down. The preceding analysis shows, however, that this incentive will be less, the greater is the elasticity of supply of the raw material. Viewed another way, even if there is relatively little buyer concentration, there may be a strong incentive to collude if supply is sufficiently inelastic.