AGRICULTURAL SELLING CARTELS: RELATIVE CO-OPERATOR AND NON CO-OPERATOR GAINS*

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An analytical framework is developed for assessing the relative gains accruing to co-operators and non co-operators in a cartel arrangement involving production quotas. Key parameters determining the relative gains are identified. The values of these parameters in the context of Australian agriculture could result in greater gains for non co-operators than for co-operators. Suggestions are offered on some types of information that should be sought in feasibility studies before cartels are established.

It is well known that agricultural selling cartels which restrict supply to increase producer incomes frequently provide greater benefits for those who choose to sell outside the cartel (non co-operators) than for those who choose to sell through the cartel (co-operators). Galbraith (1957, ch. 11) described how this resulted in the demise of Sapiro-type co-operatives, while Helmberger and Hoos (1965), Jamison (1971) and Campbell (1973) described how non co-operators constitute a problem for bargaining co-operatives, market-order authorities and marketing boards, respectively.

In this paper, an analytical framework is developed for comparing the gains received by co-operators in a supply-restricting cartel against those received by non co-operators. While the gains accruing to an individual producer will depend upon his particular cost structure, the analysis herein is in terms of industry-level parameters. By identifying the key parameters which determine the relative gains received by co-operators and non co-operators, the analysis should be of some use in the assessment of the chances of long-run survival for certain cartels. Hopefully, the analysis will constitute a partial response to an observation by Campbell (1973, p.188):

> It is evident . . . that most farmers have a poor appreciation of the limits to the market power which the producer-managed boards may exercise and the gains in prices which they may achieve . . . There needs to be better recognition that producer-controlled marketing boards are not equally suitable to all marketing situations and indeed to all commodities.

The paper is structured as follows. Some relevant firm-level considerations are presented and a justification is provided for an analysis in terms of industry-level parameters. Such an analysis is outlined, followed by a discussion of its limitations. Finally, the analysis is applied in the context of Australian agriculture, with the discussion covering marketing board

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feasibility studies, parameter ranges and some considerations involved in the design of penalty structures.

Firm-Level Considerations

Lipsey (1979, pp. 290-1) and others have provided simple expositions of the non co-operator problem facing agricultural selling cartels, ending with the conclusion that these cartels inevitably fail. This conclusion is not surprising, given the assumption that producers have identical cost structures: if a producer's cost structure were unaffected by-remaining a non co-operator, he would have the incentive to let others restrict supply while selling as much as he wished at the price level established by the cartel. The fact that some supply-restricting cartels survive suggests that these simple expositions are inadequate.

The fines which compulsory cartels can impose would act as a deterrent for some producers who would otherwise be non co-operators. However, a cartel might also provide excludable cost-reducing benefits to co-operators, as well as imposing additional costs. In short, the assumption that co-operators and non co-operators have identical cost structures seems restrictive.

Whether a particular producer chooses to abide by the cartel rules will depend on the ratio of the gains he receives as a non co-operator to those he receives as a co-operator. For purposes of predicting the long-run stability of a particular cartel, it would be useful to know the parameters of the frequency distribution of this ratio. Given that agricultural industries are typically composed of large numbers of producers, and given the problems of measuring costs of production, a measure of comparative gains expressed in terms of industry-level parameters would be a useful alternative, provided its limitations were appreciated. Such a measure is developed in the following section.

Industry-Level Analysis

Suppose a cartel is formed among a group of producers selling to buyers who act as price-takers. The primary aim of the cartel is to increase co-operators' net incomes. While the cartel might attempt to do this in a number of ways, it is assumed here that the objective is pursued by imposing quotas on output.

The cartel would share the market with two types of non co-operators: those having no legal obligation to sell through the cartel (these would include interstate traders in the case of Australia's State marketing boards) and those who risk prosecution by selling outside the cartel. These non co-operators choose to sell outside the cartel because of greater expected gains. For the illegal traders, the comparison of expected gains would take account of the costs associated with detection, but these are ignored temporarily.

Provided the quality of the non co-operators' output is equal to that of co-operators, then at any price above the competitive equilibrium, the cartel would face a residual demand (D_c in Figure 1) equal to the difference between total demand (D_t) and non co-operator supply (S_n).

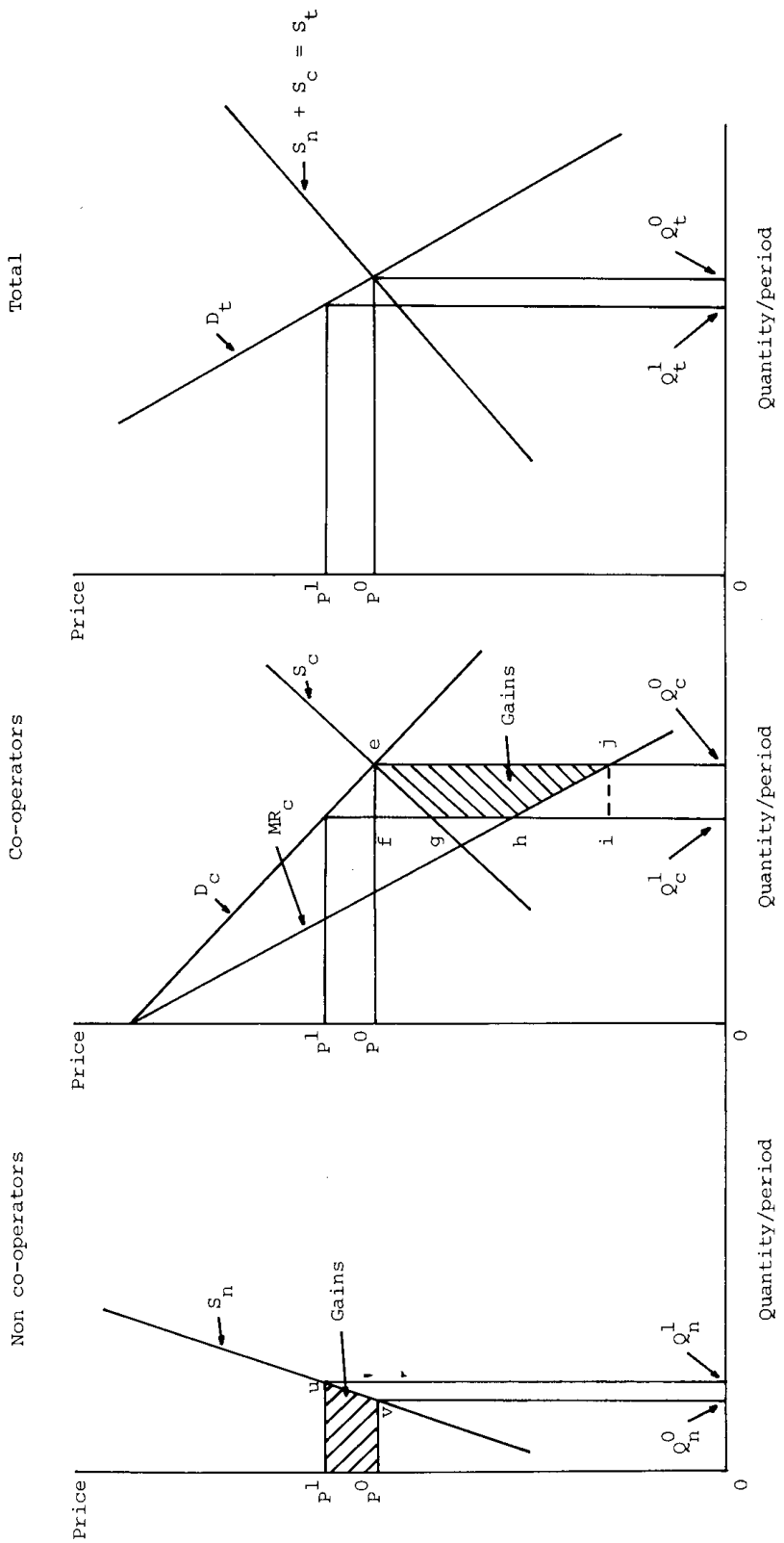

FIGURE 1—Co-operator and non co-operator gains from supply restriction.

That is:

$$D_c = D_t - S_n. \tag{1}$$

The price elasticity of demand confronting the cartel will, in general, be more elastic than the total demand and is given by:

$$e_2 = w(e_1 - s_1) + e_1, \tag{2}$$

where e_1 = price elasticity of total demand;
e_2 = price elasticity of cartel demand;
s_1 = price elasticity of non co-operator supply; and
w = S_n/D_c (ratio of purchases from non co-operators to purchases from co-operators).

The supply functions in Figure 1 should be interpreted as short-run functions relevant to the period over which cartel membership is fixed. They reflect the cost structures of non co-operators and co-operators. One cannot generalise concerning the relative shapes of these functions. These will depend on considerations such as whether it is mainly high-cost or low-cost producers who opt to co-operate and the net effect of the cartel on cost structures.

Aggregate gains from supply restrictions

Short-run gains accruing to co-operators and non co-operators are shown by the hatched areas in Figure 1. If the cartel restricted output from Q_c^o to, say, Q_c^1, gains (area $eghj$) would accrue to the cartel because the saving in total cost $Q_c^1 geQ_c^o$ would exceed the loss in total revenue ($Q_c^1 hjQ_c^o$). In Figure 1, $|e_2| > 1.0$ at Q_c^o (cartel marginal revenue, MR_c, is positive), but it is possible for $|e_2| < 1$, in which case MR_c would be negative and the cartel would obtain a revenue increase, along with a cost decrease, by restricting output.

If the cartel restricts output from Q_c^o to Q_c^1, price rises from P^o to P^1, total quantity demanded contracts from Q_t^o to Q_t^1, but the quantity supplied by non co-operators expands from Q_n^o to Q_n^1. As a result, the producer surplus accruing to non co-operators as a group increases by the area P^oP^1uv.

If it is assumed that the actual supply and demand functions can be approximated by linear functions over the relevant range—an assumption often made in evaluating social costs of agricultural programs, as in Johnson (1965) and Wallace (1962)—the hatched areas in Figure 1 can be expressed in terms of the proportionate change in cartel sales and the various elasticities and revenues at the competitive equilibrium (see Appendix).[1] In particular:

$$G_c = (R_c^o/e_2)z + (R_c^o/e_2)z^2 - (R_c^o/2s_2)z^2 \tag{3}$$

[1] If the various demand and supply functions are linear, the formulae developed herein would be exact. If the various functions are approximately linear, then the formulae will, of course, only approximate the relevant areas. As indicated by Wallace (1962, p. 594), 'For small changes about equilibrium, the approximation formulae are likely not too misleading'.

and

$$G_n = (R_n^o/e_2)z + (R_n^o s_1/2e_2^2)z^2, \quad (4)$$

where G_c = gain to co-operators (dollars);
G_n = gain to non co-operators (dollars);
$R_c^o = P^o Q_c^o$ (revenue from cartel sales);
$R_n^o = P^o Q_n^o$ (revenue from non co-operators' sales);
$z = \triangle Q_c/Q_c^o$ (proportionate change in cartel sales); and
s_2 = price elasticity of cartel supply (S_c in Figure 1).

After substituting (2) into (3) and (4), partial differentiation provides the relationships shown in Table 1. In summary, co-operator and non co-operator gains will be greater the greater the reduction in cartel supply and the less elastic is total demand. On the other hand, they will be less, the greater is the proportion of total demand met from non co-operator supplies. The greater the non co-operator supply elasticity, the smaller the gains to the co-operators and (probably) the greater the gains accru-

TABLE 1

Partial Derivatives of Co-operator and Non Co-operator Gains[a]

Partial derivative	Sign	Explanation
$\delta G_c/\delta z$	<0	Negative provided $z > s_2/(e_2 - 2s_2)$; i.e. provided cartel output is not reduced below profit maximising output (see Appendix). If $MR_c < MC_c$, output restriction increases profit.
$\delta G_c/\delta e_1$	>0	More inelastic is total demand → more inelastic is cartel demand smaller the loss (greater the gain) in revenue from restricting output.
$\delta G_c/\delta s_1$	<0	Greater is non co-operators' supply elasticity → more elastic is cartel demand → greater the loss (smaller the gain) in revenue from restricting output.
$\delta G_c/\delta s_2$	>0	More elastic is cartel supply → greater the cost saving from restricting output.
$\delta G_c/\delta w$	<0	Greater the ratio of non co-operator to co-operator sales → more elastic is cartel demand → greater the loss (smaller the gain) in revenue from restricting output.
$\delta G_n/\delta z$	<0	Greater the reduction in cartel output → greater the price increase → greater the increase in non co-operators' producer surplus.
$\delta G_n/\delta e_1$	>0	More inelastic total demand → more inelastic cartel demand → greater the price rise → greater the non co-operators' producer surplus.
$\delta G_n/\delta s_1$	$>$ $=0$ $<$	Positive if $s_1 > (-0.5e_2/w) - (e_2/z)$ → probably the case. Offsetting forces. The greater is non co-operators' supply elasticity → bigger the increase in producer surplus for a given price change. But the greater is non co-operators' supply elasticity → greater is cartel demand elasticity → smaller the price rise.
$\delta G_n/\delta s_2$	$=0$	Gain to non co-operators independent of cartel supply elasticity.
$\delta G_n/\delta w$	<0	Greater is ratio of non co-operator to cartel sales → more elastic is cartel demand → smaller the price rise → smaller the increase in non co-operators' producer surplus.

[a] z = proportionate change in cartel supplies (<0); w = ratio of non co-operator to co-operator sales at competitive equilibrium (>0); e_1 = price elasticity of total demand (<0); e_2 = price elasticity of cartel demand (>0); s_1 = price elasticity of non co-operators' supply (>0); s_2 = price elasticity of co-operators' supply (>0).

ing to non co-operators. Co-operators' gains increase directly with the elasticity of cartel supply. However, this parameter does not affect the gains accruing to non co-operators.

Relative co-operator and non co-operator gains

The gains accruing to individual producers will differ because of differing cost structures. However, the average gain accruing to co-operators can be compared against the average gain accruing to non co-operators. Although this measure of relative gains has certain limitations, which are discussed later, it seems to be a logical one, short of analysing individual producers' cost structures. The cartel which can provide an average gain across co-operators exceeding the average gain across non co-operators should have a greater chance of survival in the long run.

Suppose we define:

$$I = (G_n/N)/(G_c/M), \tag{5}$$

where G_n/N and G_c/M measure, respectively, the average gain accruing to non co-operators and co-operators; and
N and M represent, respectively, the number of non co-operators and the number of co-operators.

If I exceeds 1.0, then, on average, non co-operators gain more than co-operators.

Substituting (3) and (4) into (5) yields:

$$I = k[1 + (s_1 z/2e_2)]/[1 + z - (e_2 z/2s_2)], \tag{6}$$

where k = average non co-operator output/average co-operator output.

Values for I corresponding to various parameter values are shown in Table 2. The parameter values need to be chosen carefully. Recall that e_2 is a linear function of w, e_1 and s_1. As well, w (the ratio of non co-operator to cartel sales at the competitive equilibrium) is the product of k (ratio of average production) and x, where x is the ratio of the number of non co-operators to the number of co-operators. In choosing parameter values for Table 2, x has been fixed at 0.111 (1 non co-operator for every 9 co-operators).[2] Specification of x, k, e_1 and s_1 determines the values for w and e_2. For the parameter values used in Table 3, w ranges from 0.083 to 0.139 and e_2 ranges from -0.56 to -1.81.

The value of I exceeds unity for many of the parameter combinations in Table 2. It can be shown that a necessary condition for I to be less than unity is that k is less than unity (average co-operator output exceeds average non co-operator output). After substituting (2) into (6) and partially differentiating, it is found that I increases directly with k and the absolute value of z, but inversely with s_2. The signs of the derivatives with respect to e_1, s_1 and w are uncertain. However, for the range of parameter values shown in Table 2, I increases with s_1.

[2] To check the sensitivity of the index to changes in x, values of I were also computed using $x = 0.25$ and setting the other parameters at the extreme values used in Table 2. This change caused the values of I to change only at the second, and sometimes only the third, decimal place.

TABLE 2

Values of the Ratio of Average Non Co-operator Gains to Average Cartel Gains (I)[a]

		s_1, s_2								
k	e_1	.25, .25	.25, .50	.25, .75	.50, .25	.50, .50	.50, .75	.75, .25	.75, .50	.75, .75
0.75	−0.5	0.848	0.823	0.814	0.859	0.832	0.823	0.869	0.841	0.832
0.75	−1.0	0.898	0.843	0.826	0.905	0.848	0.831	0.912	0.854	0.836
0.75	−1.5	0.959	0.868	0.841	0.965	0.872	0.845	0.971	0.876	0.848
1.00	−0.5	1.134	1.098	1.086	1.148	1.110	1.100	1.162	1.121	1.108
1.00	−1.0	1.203	1.126	1.102	1.213	1.134	1.109	1.223	1.141	1.116
1.00	−1.5	1.286	1.160	1.123	1.295	1.166	1.128	1.304	1.172	1.134
1.25	−0.5	1.420	1.373	1.358	1.438	1.388	1.372	1.456	1.402	1.385
1.25	−1.0	1.509	1.410	1.380	1.523	1.420	1.388	1.537	1.429	1.397
1.25	−1.5	1.617	1.454	1.407	1.630	1.462	1.413	1.643	1.470	1.420
0.75	−0.5	0.974	0.909	0.889	0.998	0.929	0.908	1.022	0.949	0.927
0.75	−1.0	1.117	0.961	0.918	1.136	0.974	0.929	1.155	0.986	0.940
0.75	−1.5	1.324	1.028	0.956	1.343	1.038	0.965	1.363	1.048	0.974
1.00	−0.5	1.304	1.214	1.186	1.338	1.241	1.211	1.371	1.266	1.235
1.00	−1.0	1.504	1.286	1.227	1.532	1.304	1.242	1.560	1.321	1.257
1.00	−1.5	1.795	1.379	1.280	1.826	1.394	1.292	1.857	1.409	1.304
1.25	−0.5	1.637	1.520	1.484	1.682	1.554	1.515	1.724	1.584	1.543
1.25	−1.0	1.899	1.614	1.537	1.938	1.637	1.557	1.977	1.660	1.576
1.25	−1.5	2.283	1.735	1.606	2.328	1.755	1.622	2.373	1.775	1.637

[a] k is the ratio of average non co-operator to average co-operator production; e_1 is the elasticity of total demand and s_1, s_2 are the elasticities of non co-operators' and co-operators' supply, respectively. The value of x (ratio of the number of non co-operators to the number of co-operators) has been set at 0.1111. The implicit values for w (ratio of purchases from non co-operators to purchases from co-operators) range from 0.083 to 0.139 and the implicit values for e_2 (cartel demand elasticity) range from −0.56 to −1.81.

There are two special cases of interest. The first is where the cartel limits supply to the level at which cartel marginal revenue and marginal cost are equated (profit maximisation). Under these circumstances (see Appendix):

$$I = 2k + [(ks_1s_2)/(e_2^2 - 2e_2s_2)] \tag{7}$$
$$= I^*.$$

The other case is where the cartel marginal revenue is negative at the competitive equilibrium and the cartel limits supply to the level at which cartel marginal revenue is zero (revenue maximisation). Under these circumstances (see Appendix):

$$I = k[4e_2s_2 - e_2s_1s_2 - s_1s_2]/[2e_2s_2 - 2e_2^2 s_2 + e_2^2 + e_2^3] \tag{8}$$
$$= I^{\#}.$$

It needs to be emphasised, however, that both these policies, and especially the first, may entail large percentage reductions in cartel supply.[3] This being the case, using the formulae for I^* and $I^{\#}$ may give

[3] It is shown in the Appendix that, for a policy of equating cartel marginal revenue and marginal cost, $z = s_2/(e_2 - 2s_2)$; for a policy of maximising revenue, $z = -0.5(e_2 + 1)$.

TABLE 3

Comparative Values of the Ratio of Average Gains—Profit Maximisation (I^*) vs. Revenue Maximisation ($I^\#$)[a]

s_1	s_2	e_1	z^*	I^*	$I^\#$
0.2	0.2	−0.79	−0.154	2.034	1.201
0.2	0.4	−0.79	−0.235	2.052	1.125
0.2	0.6	−0.79	−0.286	2.063	1.102
0.4	0.2	−0.77	−0.154	2.068	1.207
0.4	0.4	−0.77	−0.235	2.105	1.131
0.4	0.6	−0.77	−0.286	2.127	1.108
0.6	0.2	−0.75	−0.154	2.103	1.214
0.6	0.4	−0.75	−0.235	2.157	1.138
0.6	0.6	−0.75	−0.286	2.190	1.114

[a] s_1 and s_2 are, respectively, the price elasticities of non co-operators' and co-operators' supply, e_1 is the price elasticity of total demand and z^* is the proportionate change in cartel supply consistent with cartel profit maximisation. Implicit parameter values are $k = 1.0$ (the ratio of non co-operator to co-operator average production); $w = 0.1111$ (the ratio of non co-operator to cartel sales); $e_2 = -0.9$ (the cartel demand elasticity) and $z\# = -0.05$ (the proportionate change in cartel supply consistent with revenue maximisation). Parameter values were chosen such that $z^* > -0.3$.

misleading estimates of the ratio of average gains if the various supply and demand functions are non-linear.

Values for I^* and $I^\#$ corresponding to various parameter values are shown in Table 3. The values of I^* tend to be almost twice as large as the values of $I^\#$.

Limitations

The analysis is applicable to situations in which buyers act as price-takers. If individual buyers can influence prices through variations in the quantity purchased, the concept of a demand function is not meaningful (Friedman 1962, p. 178). In these situations, there is simultaneous determination of price and quantity purchased by the individual firm. However, if these buyers have to obtain part of their requirements from a cartel at a price level established through a bargaining process, it is possible to define a hypothetical demand function over a certain price range (Friedman 1962, p. 188). This curve would indicate the profit-maximising level of purchases corresponding to each negotiated price or marginal factor cost. While the cartel might negotiate both price and quantity increases over some price range, there will be a range of prices over which price increases result in decreased purchases from the cartel, as in Figure 1.

Although it has been assumed that the cartel controls product flow through production quotas, cartels (including Sapiro co-operatives) have often achieved this through supply diversion. The gains defined in Figure 1 do not reflect the gains which result when supply diversion, rather than production quotas, is the control mechanism. Assuming co-operators are paid a weighted average price for all their output, the price received by non co-operators would exceed the price received by co-operators, since the non co-operators would opt to sell their output on the highest-priced market. As well, co-operators' output would probably be greater than in

the absence of the cartel, so increased (rather than decreased) total production costs, along with increased revenue, have to be taken into account when figuring the profit gains. However, it seems reasonable to conclude that the need for the cartel to provide cost-reducing benefits to co-operators would be greater under supply diversion compared to production quotas, since the price received at the margin by non co-operators would exceed the (weighted average) price received by co-operators.

Input restrictions have also been used to control product flow. The relative gains in this case depend on the extent to which other inputs can be substituted for the restricted input and whether input restrictions can be imposed on non co-operators. The gains shown in Figure 1 are consistent with those which would result from restrictions on co-operators' use of an essential input (defined as one whose planned use is proportional or nearly proportional to planned output), assuming non co-operators' use of the input cannot be restricted. Such would be the case for a State marketing board which restricted the use of an essential input within its own State, but was unable to restrict the use of the input in other States. A restriction on the use of the input is equivalent to a quota on output and would be represented by a movement along S_c in Figure 1. However, if other inputs can be substituted for the restricted input, S_c would no longer be the appropriate supply function, assuming producers switch to higher-cost input combinations. Provided the input restrictions cannot be imposed on non co-operators, then the values for I shown in Table 2 would understate the true values, since the producer surplus earned by co-operators at any price level would be less than in the case of quotas on output.

Generalisations regarding the size of relative gains are more difficult when input restrictions can be imposed on all producers. In the case of an essential input, it is conceivable that non co-operators could be prevented from employing any of the input, in which case their output would be zero. If they do have access to the input, then S_n in Figure 1 remains the relevant supply function, but their combined output level would depend on how much of the input can be obtained. If the input is not essential, one would expect an upward shift in S_n as higher-cost input combinations are used and the increase in their producer surplus would be less than that shown in Figure 1.

Another limitation concerns the use of the ratio of average gains as a measure of the relative gains, since it does not take into account the variability in gains across individual producers. This can be considered as a cost of using a measure which can be expressed in terms of industry-level parameters. The degree of variation in individual producer output levels will be an important determinant of the degree of variation in individual gains. As well, since non co-operators will expand their output in response to the higher price, differences in the elasticity of their marginal cost functions will result in differences in gains among non co-operators.

The measure of relative gains that has been used would be misleading if there were a tendency for those producers receiving below average gains as co-operators to receive higher than average gains as non co-operators, and vice-versa. While this is possible, it does not seem probable since it implies substantial changes in the pattern of relative efficien-

cies among producers. Assuming that an individual producer's gain bears approximately the same relationship to the group average whether he be a non co-operator or a co-operator, the ratio of average gains should be a reasonable measure of the relative gains accruing to that producer.

Application

As indicated by Campbell (1973, p. 180), there is a high degree of automation in the procedure for the establishment of marketing boards in Australia. In particular, it appears that very little research is undertaken to determine the economic feasibility of boards prior to their establishment. In this section, suggestions on some types of information that should be useful in judging the economic feasibility of a proposal to establish a board for the purpose of increasing producer incomes through production quotas, are given. Attention is also given to the likely magnitude of some of the parameters in the context of Australian agriculture and to the design of penalty structures.

Feasibility studies

A crucial parameter determining the size of relative gains is k, the ratio of the average production of non co-operators to the average production of co-operators. Hence, feasibility studies should include some assessment of the likelihood that relatively large producers will sell through the board. Such an assessment would be difficult, but it might be based in part on whether the initial impetus for the establishment of the board was provided by mainly small or mainly large producers. Assessing the likely success of a board simply on the basis of the proportion of voters likely to be in favour could be quite misleading, especially in industries where there is marked variation in farm sizes.

Econometric analyses can help in establishing feasible ranges for the elasticity parameters. For example, an estimate of the price elasticity of total demand can be used in establishing a lower limit on the price elasticity of demand that would confront the cartel. If the elasticity of aggregate demand is close to unity, or exceeds unity, it could be concluded that any gains resulting from production quotas will be the result of cost savings in excess of revenue losses.

Estimates of the elasticity of aggregate supply would also be useful. Referring to Figure 1 , the elasticity of S_t at the price level p^o is a weighted average of the price elasticities of S_n and S_c, the weights being the proportion of total supply met from each source. Hence, an estimate of the elasticity of S_t provides a restriction to use in choosing combinations of values for the elasticities and the proportion of total supply met from each source. Consideration should also be given to the relative input combinations employed by large compared to small producers. Large producers might be less responsive to price changes if they use highly specialised inputs.

It should be noted that the smaller the cartel supply elasticity, the smaller the cost savings entailed in a given reduction in supply. This consideration would be especially important if econometric estimates of the aggregate demand function are consistent with a relatively elastic demand confronting the cartel.

Parameter magnitudes

Most Australian agricultural industries consist of producers who are quite heterogeneous with respect to output levels. Moreover, Campbell (1973, pp. 187-8) has suggested that it is mainly the larger producers who seek greater flexibility and independence in selling their output than is provided under marketing board controls. Consistent with this view, it seems that the proponents of 'orderly marketing' arrangements in the past have often been the smaller producers. Given these considerations, and ignoring temporarily the penalties that are incurred by producers found to be selling illegally, there are some grounds for believing that appropriate k values in the context of Australian agricultural industries could be close to, or in excess of, unity.

Another feature of Australian agriculture is the geographically-dispersed production areas for most commodities. Few commodities are grown in a single State. This means that State marketing boards face competition for the products they sell domestically, a factor making for an elastic demand. The highly elastic nature of the export demand for most Australian agricultural products would also make for a highly, if not perfectly, elastic demand confronting some cartels. Nevertheless, Richardson's (1976) review of estimated demand parameters led him to the conclusion that 'domestic demand for agricultural products is often both price and income inelastic' (p.96), but he noted that some meats, wine and certain other products were exceptions. It needs to be remembered, though, that published estimates should be taken as lower limits on the elasticities that would confront cartels, and that domestic demand is only part of the total demand for most products.

The evidence from Australian supply studies is consistent with relatively inelastic short-run responses to price. The range of values 0.1 to 0.8 might be used in assessing relative gains. Some would regard the figure of 0.8 as being too high, but it is consistent with the author's view that supply elasticities computed using data means are likely to be less than the elasticities computed at relatively low prices. Over relatively low price ranges, responses to price changes might take the form of variations in areas harvested and changing intensities of certain cultural practices.

Most Australian farms are multi-enterprise concerns. The supply response from non co-operators might exceed that from co-operators if there were a tendency for non co-operators to produce the 'controlled' product as a 'sideline'. One can imagine non co-operators holding some resources in reserve to take advantage of favourable prices established by the cartel.

Estimates of the extent of illegal selling of commodities under the control of boards have to be treated with caution. In the case of wheat, the various estimates have been around 10-20 per cent of the crop, with the percentage increasing as the differential between domestic and export prices increases (IAC 1978, p.10). The percentage may be greater for eggs. Figures on 'unrecorded' commercial and 'backyard' production represent over 30 per cent of total egg production (BAE 1979, p. 27).

After considering the parameter ranges, one is unable to predict whether or not I would generally exceed unity. However, the point to be emphasised is that the ranges are not inconsistent with I values in excess of unity. Certainly there is a need for a careful assessment of key

parameters before the establishment of marketing boards for the purpose of restricting supply through production quotas.

Although some marketing boards have survived for only a short time, others have had a lengthy existence and some of these (tobacco, rice, dried-vine fruits) have used quotas on production or essential inputs as a means of income enhancement. As indicated by Longworth (1972, p. 58), the relatively small geographical area in which some commodities are grown has been a factor contributing to longevity. Detection of non co-operators is easier and there are no producers located outside the board's area of jurisdiction.

Some boards have been able to control essential inputs (water in the case of rice) so as to eliminate the non co-operator problem. Another control mechanism available to some boards is their power to license processing and packing houses. These licensing powers might well be their means of overcoming the non co-operator problem.

Penalty structures

There are a number of considerations involved in designing a penalty structure to eliminate non co-operation. Some of these follow from the preceding analysis, but the discussion below includes others.

The longevity of a cartel would be jeopardised by new entrants in the long-run. There will be an incentive for entry as long as the cartel increases price above the competitive level. Hence, not only must the penalty be sufficient to entice existing non co-operators into the cartel, it has to be sufficient to force expected gains for illegal entrants below zero.

The relevant tradeoff to be considered by a non co-operator is the expected (discounted) future cost of prosecution plus the expected (discounted) adjustment costs following prosecution, versus the expected (discounted) gains accrued prior to prosecution. Marketing boards are able to influence the expected cost of prosecution through the fine imposed. There are various reasons why the minimum effective fine will differ among non co-operators. Their expected gains from the cartel's supply control activities will differ, as will their estimates of the probability of being detected. Although it can be expected that, for all non co-operators, the disutility of the loss associated with detection will increase with the amount of the fine, the rate of increase will differ among them.

The probability of detecting a non co-operator would probably increase following the first offence. Ultimately the non co-operator would be forced to cease production or join the cartel, both of which result in adjustment costs. These costs are also likely to differ among non co-operators.

Given that the minimum effective penalty will differ among non co-operators, one alternative is to set a penalty sufficiently high to deter all potential non co-operators. However, such a penalty may be unacceptable to society. In setting a lower penalty rate, the cartel would need to consider the increased detection costs and the higher frequency of court appearances which are probably associated with lower penalties. Furthermore, the prosecution process probably does little to enhance the public image of cartels.

The analytical framework does not provide all the information re-

quired for the design of an 'optimal' penalty structure. However, insofar as the optimal penalty increases with the size of the average gain received by non co-operators, then some of the parameters that need to be considered are apparent from the preceding analysis.

Conclusions

When an agricultural selling cartel such as a marketing board or co-operative attempts to increase producers' incomes through production quotas, gains accrue to co-operators and non co-operators alike. The crucial parameters determining the relative size of these gains are the price elasticity of demand for the product concerned, the price elasticities of co-operator and non co-operator supplies, the average output produced by non co-operators compared to co-operators and the proportionate reduction in supply imposed by the cartel.

For certain parameter combinations, the average gain received by non co-operators will exceed the average gain received by co-operators. These parameter combinations seem possible in the context of Australian agriculture. Under these conditions, and in the absence of penalties, there would be an incentive for the 'average producer' to become a non co-operator. While compulsory cartels can eliminate this incentive through penalties, voluntary cartels would need to provide excludable benefits to co-operators which are sufficient to increase their net returns above those of non co-operators. As well, long-run stability of the cartel would require restrictions on entry.

Unlike some previous expositions of the non co-operator problem, the analysis in this paper does not lead one to the conclusion that agricultural cartels inevitably fail. It is possible for co-operators to gain more than non co-operators. Whether it is probable can be determined only after a careful study of the key parameters in each particular case.

APPENDIX

Derivation of the Gains Formulae

Notation

All elasticities defined below are price elasticities evaluated at the competitive equilibrium. Furthermore, the c subscript denotes co-operator; the n subscript denotes non co-operator; the o superscript indicates a competitive equilibrium value and the 1 superscript indicates a value determined at the new equilibrium following the cartel supply reduction. The remaining notation is listed below:

G = total gain;
N = number of non co-operators;
M = number of co-operators;
$I = [G_n/N]/[G_c/M]$;
k = ratio of non co-operator to co-operator average production;

w = ratio of non co-operator to co-operator sales at the competitive equilibrium;
p = price;
Q = quantity traded;
$\triangle$ = change (in whatever variable follows '$\triangle$');
R = total revenue;
MR = marginal revenue;
MC = marginal cost;
e_1 = elasticity of total demand;
e_2 = elasticity of cartel demand;
s_1 = elasticity of non co-operator supply;
s_2 = elasticity of cartel supply; and
z = proportionate change in cartel quantity traded.

Co-operators' gain

This is given by area *hgej* in Figure 1. This area is equal to area *efij* minus the areas *efg* and *hij*. (The gains would be defined analagously when MR_c^o is negative.)

The following relationships hold:

$$\begin{aligned} ej &= P^o - MR_c^o; \\ MR_c^o &= P^o + (P^o/e_2); \\ fg &= P^o \triangle Q_c / s_2 Q_c^o; \\ \triangle P &= P^o \triangle Q_c / e_2 Q_c^o; \\ &= P^o z / e_2; \text{ and} \\ hi &= 2\triangle P. \end{aligned}$$

Upon substitution, and bearing in mind that $\triangle Q_c$ is negative, it follows that:

$$\begin{aligned} G_c = & -[P^o - (P^o + (P^o/e_2))]\triangle Q_c \\ & + [0.5\triangle Q_c][2P^o \triangle Q_c / e_2 Q_c^o] \\ & - [0.5\triangle Q_c][P^o \triangle Q_c / s_2 Q_c^o], \end{aligned}$$

which simplifies to:

$$G_c = (R_c^o/e_2)z + (R_c^o/e_2)z^2 - (R_c^o/2s_2)z^2. \tag{A.1}$$

Non Co-operators' gain

This is given by the area P^oP^1uv in Figure 1. Note that:

$$\triangle Q_n = s_2 \triangle P Q_n^o / P^o.$$

Hence,

$$\begin{aligned} G_n &= [\triangle P Q_n] + [.5\triangle P \triangle Q_n] \\ &= [\triangle P Q_n] + [.5\triangle P s_1 \triangle P Q_n^o / P^o] \\ &= [P^o \triangle Q_c Q_n^o / e_2 Q_c^o] + [.5 s_1 P^o Q_n^o (\triangle Q_c)^2] / [e_2^2 (Q_c^o)^2]. \end{aligned}$$

This simplifies to:

$$G_n = (R_n^o/e_2)z + (R_n^o s_1 / 2e_2^2)z^2. \tag{A.2}$$

Relative gains

The general form is given by equation (6) in the text, reproduced below as:

$$I = k[1 + (s_1 z/2e_2)]/[1 + z - (e_2 z/2s_2)]. \tag{A.3}$$

In the special case of cartel profit maximisation, supply is restricted to the level at which $MR_c = MC_c = V$. Let $\triangle MR = V - MR_c^o$ and let $\triangle MC = V - MC_c^o$.

Then
$$\begin{aligned} \triangle MR - \triangle MC &= MC_c^o - MR_c^o \\ &= P^o - MR_c^o \\ &= -P^o/e_2. \end{aligned}$$

But
$$\begin{aligned} \triangle MR &= 2\triangle P \\ &= 2P^o z/e_2 \end{aligned}$$

and $\triangle MC = P^o z/s_2$ (from supply elasticity formula).

Hence, $2P^o z/e_2 - P^o z/s_2 = -P^o/e_2$, and

$$z = s_2/(e_2 - 2s_2) = z^*. \tag{A.4}$$

Substitution for z in (A.3) and re-arranging yields:

$$\begin{aligned} I &= 2k + [(ks_1 s_2)/(e_2^2 - 2e_2 s_2)] \\ &= I^*. \end{aligned} \tag{A.5}$$

The special case of cartel revenue maximisation refers to the situation in which MR_c^o is negative and the cartel selects $z = z\#$ such that MR_c is zero. (The case in which MR_c^o is positive and the cartel expands sales to the point at which MR_c equals zero is not analysed—such a strategy would entail shifting the cartel supply function to the right.)

From the general formula for price elasticity of demand:

$$\begin{aligned} \triangle Q_c &= e_2 Q_c^o \triangle P/P^o, \text{ or} \\ &= e_2 Q_c^o (0.5\triangle MR)/P^o. \end{aligned} \tag{A.6}$$

If MR_c^o is negative, a policy of revenue maximisation requires that:

$$\begin{aligned} \triangle MR &= -MR_c^o \\ &= -P_o[1 + (1/e_2)]. \end{aligned}$$

Substituting in (A.6) for $\triangle MR$ and re-arranging yields:

$$z = -0.5(e_2 + 1) = z\# \tag{A.7}$$

and substituting in (A.3) for z yields:

$$\begin{aligned} I &= k[4e_2 s_2 - e_2 s_1 s_2 - s_1 s_2]/[2e_2 s_2 - 2e_2^2 s_2 + e_2^2 + e_2^3] \\ &= I^\#. \end{aligned} \tag{A.8}$$

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