STABILIZATION WITH A DEFICIENCY PAYMENT PROGRAM - SOME THEORETICAL CONSIDERATIONS AND EMPIRICAL ANALYSIS FROM THE CANADIAN SITUATION

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Canada has recently embarked on an agricultural stabilization policy which includes a number of individual commodity programs. These rely on deficiency payments as the policy instrument. To date programs have been introduced for Canadian beef cattle and hogs. Given the economic environment in which Canada's agriculture exists, there are a number of considerations which are important for the analysis of long range costs and benefits of these programs. First, when trade in livestock products between Canada and the United States occurs, we are faced with an open economy situation in which only one partner is participating in the program.[1/] Second, since Canada represents only a fraction of the total North American market for pork and beef (approximately 10 percent), Canadian prices are established exogenously. Therefore, any supply response resulting from the Canadian program will have little effect on these prices. Third, the cyclical nature of the markets for livestock means that the effects of the programs cannot be measured instantaneously. Rather, they must be measured over time in a lagged adjustment framework.

A number of recent studies have analyzed the costs and benefits of commodity price stabilization. Most of these studies have started from one of several premises which limit the applicability of their results to the analysis of costs and benefits of programs of the type developed in Canada. These limitations include: first, a closed economy approach, e.g. Massell, Turnovsky and Just; or, second, an open economy approach which includes parti-

cipation by a number of trading partners, e.g. Hueth and Schmitz. Each of these studies considers costless inventory management as the only policy instrument, and, with the exceptions of Turnovsky and Just, assumes instantaneous adjustments of production to price changes.

The results of these studies, in essence, are that commodity price stabilization leads to net gains to all participants in the market provided compensation is made by the gainers to the losers. The source of instability is crucial in determining who are the gainers and losers. Specifically, producers in an open economy benefit from commodity price stabilization achieved through costless international stock management when the instability is generated by fluctuating yields or costs of production in that country. Consumers in all economies and other producers lose. Conversely, consumers gain from similar stabilization measures when the source of fluctuation is their demand function; consumers in other economies and producers everywhere lose.

The welfare implications of these conclusions seem applicable to the Canadian hog economy. Assuming that North American pork prices are determined in the U.S. market, they suggest that it would not be in Canada's interest to join with the U.S. in a price stabilization program. However, the policy instrument currently being used is not costless international stock management but, as stated above, a deficiency payments program implemented only in Canada. Hence, the direct application to the Canadian hog economy of policy conclusions stemming from existing welfare analyses may be misleading.

This paper, therefore, has three objectives. The first is to extend the framework of the studies cited above to evaluate the potential net economic benefits of programs such as Canada's. The second is to show, with an empirical analysis of price and margin deficiency programs for the Canadian pork sector,

the actual benefits resulting from such programs. The third is to compare the stabilizing effects of these two policy instruments.

Welfare Analysis of Stabilization with a Price Deficiency Payment Program

The following model represents a commodity market in a country that is a net exporter of the good. It is assumed that price is determined exogenously and that only two values P_0 and P_1 pertain cyclically. Furthermore, production takes place with a time lag of one period.

(1) Demand: $q_t^d = A - a P_t$

(2) Domestic Supply: $q_t^s = -B + b P_t^*$

(3) Price Expectations: $P_t^* = P_{t-1}$

(4) Exogenous Price: $P_t = \begin{cases} P_0 \\ P_1 \end{cases}$

The objective of this section is to analyze the impact on producer surplus of the implementation of a price deficiency payment program in the situation where domestic price depends solely on the external price. To obtain the usual measure of producer surplus at a given level of output (namely, total revenue less total variable cost), equation (2) has to be rearranged to express cost as a function of the planned level of output.[2/] Substituting equation (3) into equation (2) and rearranging gives,

(5) $MC_t = P_{t-1} = 1/b\ q_t^s + B/b$

$= \beta_0 q_t^s + \beta_1$ where $\beta_0 = 1/b$ and $\beta_1 = B/b$

Hence total variable costs at time period t are,

(6) $C_t = \int_0^{q_t} (\beta_1 + \beta_0 q)\, dq$.[3/]

Producer surplus is defined as

$$S_t^P = P_t q_t - C_t$$

$$= P_t\, q_t - \int_0^{q_t} (\beta_1 + \beta_0\, q)\, dq$$

which, after integration and substitution of equation (5) yields,

(7) $S_t^p = q_t\,(P_t - P_{t-1}) + \beta_0/2\; q_t^2$.

From equation (7), the value of producer surplus may be calculated for any level of output.

Suppose that in the first time period $P_{t-1} = P_0$ in Figure 1A, then $q_t = q_1$ from equation (2). However, since there is a production lag, by the time the commodity is marketed, the second time period price has risen to $P_t = P_1$ and producer revenue is actually $P_1\, q_1$ and not that anticipated, $P_0\, q_1$. Since costs are based on the planned level of output, they are unchanged at C_1 and equal to $\beta_1\, q_1 + \beta_0/2\; q_1^2$. The first term in equation (7) is a_1 and the second is a_2 (Figure 1A).[4/] Therefore, producer surplus when P_1 pertains, $S_{f,1}^p$, is given by,

(8) $S_{f,1}^p = a_1 + a_2$.

Now, in the second period producers respond to P_1 and the level of output is q_2. By the time q_2 is marketed in the third time period, price has fallen to $P_2 = P_0$. Anticipated revenue of $P_1\, q_2$ is not realized while total costs remain at C_2 (equation 6). In equation (7), the first term gives the area $-(a_1 + a_3 + b_2)$ and the second term gives $a_1 + a_2 + a_3$. The algebraic sum of the two yields,

(9) $S_{f,2}^p = (a_2 - b_2)$.

Assume now that a producer price deficiency payment program is introduced such that producers receive the payment whenever the market price falls below the guaranteed price. Let the guaranteed price be P_g. The model as represented by equations (1) - (4) then needs to be modified. Specifically, equation (3) becomes,

$$(3') \quad P_t^* = \begin{cases} P_{t-1} \text{ if } P_{t-1} \geq P_g \\ P_g \text{ otherwise,} \end{cases}$$

and an equation is added indicating the tax costs of the program,

$$(4') \quad T_t = (P_g - P_t)\, q_t^s.$$

Figure 1A has been modified to accommodate the program (Figure 1B). Producer surplus may again be obtained for the two situations. Corresponding to equation (8), the new surplus when the guaranteed price is operating, $S_{g,1}^p$, is,

$$(8') \quad S_{g,1}^p = a_{11} + a_{31} + a_{12} + a_{32} + a_2.$$

For the second time period, when producers respond to P_1 and produce an output of q_2, the surplus $S_{g,2}^p$ is,

$$(9') \quad S_{g,2}^p = a_{12} + a_{32} + a_2 - b_{22}.$$

The gains to producers from implementation of the program may be obtained by comparing equations (8) and (8') and equations (9) and (9')

$$(10) \quad S_{g,1}^p - S_{f,1}^p = a_{11} + a_{31} + a_{12} + a_{32} + a_2 - a_{11} - a_{12} - a_2 = a_{31} + a_{32}.$$

$$(11) \quad S_{g,2}^p - S_{f,2}^p = a_{12} + a_{32} + a_2 - b_{22} - a_2 + b_{21} + b_{22} + b_{23}$$
$$= a_{12} + a_{32} + b_{21} + b_{23}.$$

Since it has been assumed that these two situations occur equally often because of the two period price cycle, the net gain to producers from the scheme, G^p is,

$$(12) \quad G^p = 1/2\ (a_{12} + a_{31} + 2a_{32} + b_{21} + b_{23}).$$

However, the tax cost must be recognized. In Figure 1B this cost is given by the area $(a_{12} + a_{32} + b_{21} + b_{23})$ since,

$$(13) \quad T_2 = (P_g - P_2)\, q_2.$$

The net benefit to the economy is then the difference between the net

benefit to producers and the tax cost. i.e.,

$$G^P - 1/2\ T = 1/2\ (a_{31} + a_{32}).$$

This area is clearly positive and it is possible to conclude that for this model and its assumptions the implementation of a price deficiency payment program benefits producers, increases the tax burden but provides a net gain overall. Moreover, it represents foreign exchange gain of $1/2\ (a_{31} + a_{32} + b_{21} + b_{31})$ since exports are increased by $P_1\ (q_g - q_1)$ in period. (i.e. when P_1 prevails).

It should be reiterated that the net gain occurs because of producer response to the deficiency payment program and because of the assumption that market prices are determined exogenously. Furthermore, the magnitude of the net benefits and the tax cost for a given response function are dependent upon the level of support included in the scheme.

Empirical Analysis

We turn now to the task of testing the theoretical results of the previous section in an empirical analysis of potential stabilization programs related to the Canadian pork sector.

The Programs

The Canadian pork stabilization program is relatively new and has most likely not reached its final form. There has been considerable debate regarding whether a program should base deficiency payments on only price or on the margin between revenue and some set of production costs. Below, two alternative programs are analyzed. Program 1 establishes a guaranteed price at 95 percent of the previous five years' moving average market price.[5/] Program 2 recognizes that pork producers' net incomes are affected by variations in the prices of factors used in production. By far the most important cost in

hog production is feed. Hence, in this program, the level of support is set at 95 percent of the five years' moving average margin above feed costs.[6/]

Method of Analysis

In analyzing a program, we want first to determine whether its benefits are as the foregoing theoretical analysis would imply. However, it is also important to assess the magnitude of any such benefits, the tax costs, and, (particularly where alternative programs are being compared) measures of the additional stability which results from the program.

To measure the impact of these programs, we use the quarterly spatial and temporal model of the North American pork sector which has been developed at the University of Guelph (see Martin and Zwart and Zwart and Martin). The model is a recursive quadratic programming procedure which predicts quarterly supplies of pork in each of three North American regions - Eastern and Western Canada and the United States. The predictions are then interfaced in the model with carry-over cold storage inventories, demand functions for consumption, demand functions for inventory, and tariff and transfer charges to determine prices, consumption levels, inventory levels and interregional trade flows. The model is recursive in that the model-generated inventory levels are carried over into each successive quarter and model-generated prices are fed through econometric supply equations to forecast pork supplies in later periods.

Martin and Zwart have shown, by validating this model over a ten year period, that it is able to approximate closely actual prices, production, consumption, trade and cold storage inventory levels in the industry (see Martin and Zwart, page 63).

The procedure for assessing the effects of a deficiency payment pro-

gram is as follows. The model is re-run for an eleven year period with the program in place. In other words, we assume that the program was initiated in 1963 and run through 1974, and our objective is to measure the effect it would have had over this period, given the econometric relationships included in the model. Several procedural steps are implicit in the exercise. First, the computer program calculates the five year moving average price and margin.[7/] Second, if 95 percent of the average price or margin in a given quarter is greater than the actual market price or margin in that quarter, a deficiency payment is calculated. Third, if a payment occurs in a quarter, the support price is used in the supply equation to forecast supply in later periods through the geometric lag relationship on which the supply equations are based. In other words, we assume that producers form their expectations and base their decisions on the prices they actually receive for pork. Fourth, the model solves for prices, consumption, trade and inventory levels for the subsequent quarters, given the supply predictions resulting from the deficiency payments. Fifth, industry gross revenue, gross margin[8/] and the tax costs resulting from the program are calculated. Sixth, the level and fluctuations in a number of variables are compared to the model's results with no program to assess the programs' impacts.

This procedure deviates from the theoretical analysis presented above in several ways. First, the theoretical analysis assumes that prices are generated exogenously and, therefore, that excess demand is perfectly elastic. In the quadratic programming model, excess demand is sloped but is extremely elastic.[9/] Moreover, it was assumed that price followed a two period cycle. This assumption is, of course, relaxed in the model.

Second, the supply equation included in the theoretical model

(equation (2)) implies a simple expectations hypothesis while the supply equations included in the recursive model are of the geometrically distributed form. Furthermore, the expectations hypothesis is applied to other variables in the supply equation besides hog prices. While this formulation does not alter the nature of the analysis, it does make calculation of producer surplus difficult, as will be noted below.

Finally, the theoretical analysis treated the case in which the country administering the stabilization program is viewed as a single homogeneous region. The empirical analysis separates Canada into two regions. The major reason for this is the institutional nature of the feed grain market in Canada which has substantially different effects on livestock supply response in the East and West. Results of the analysis are presented below for only Eastern Canada since it represents approximately 60 to 70 percent of Canadian production.

Results of the Analysis

Results of the analysis of the two programs are presented in Figures 2 through 4 and Table 1. Model-generated market prices with no program and the deficiency programs do not differ (Figure 2). Hence we can conclude that, because of the extremely elastic excess demand facing Canada, the model approximates the situation in our theoretical analysis of exogenously determined market prices.

It is clear that the two programs would have resulted in substantially different deficiency payment patterns. With Program 1, payments would have been made in 1967-68 and 1970-72 (Figure 2A). Program 2 would have resulted in payments in 1963-65, 1967-68, 1970-71 and 1973-74 (Figure 2B). Under

this program smaller payments would have been made in 1970-71 when both hog and feed prices were low. However, substantial payments would have been made in 1973-74 when hog prices were relatively high, but feed prices were at record levels.

The patterns of deficiency payments resulting from the two programs generate substantially different supply response patterns (Figure 3A and B). Program 1 would have resulted in increased supplies of pork during the period from 1971 through 1974. However, in response to the payments made under Program 2, pork production would have been increased in a number of quarters over the eleven year period.

Industry gross margin would have been altered by the program (Figure 4). Gross margin is calculated by subtracting feed costs, based on 800 pounds of feed per hog and actual feed prices, from gross revenue.[10/] Both programs would have supported gross margins during the cyclical downturns of 1967-68 and 1970-72. However, Program 2 would have added to gross margins during most quarters in the early 1960's and, more importantly, during the last quarter of 1973 and the first two quarters of 1974.

The above results show the effects the deficiency payments programs would have had over this period, and confirm our assumption that the programs in Canada would have had no effect on market prices for pork. However, they are not sufficient to confirm the results of our theoretical analysis which suggests that the net economic benefits of such a program outweigh its costs and that exports would be increased. In Table 1, the total tax costs, net benefits, in terms of industry gross revenue and gross margin, and the net change in exports are presented for the two programs over the period analyzed. Due to the formulation of the supply equation for Eastern Canada, it is not

possible to estimate producer surplus. However the change in gross margin may be a reasonable approximation. Obviously the use of gross margin as a proxy for producer surplus assumes that the marginal costs of hog production are constant and equal to marginal feed costs. Hence, the use of gross margin overestimates producers surplus in both the program and no program cases. However, the analysis would suggest that the additional gross revenue and gross margin generated by the programs exceed their tax costs. These results clearly occur because the increased supplies resulting from the deficiency payments in periods of low market prices, reach the market and are sold domestically or exported in later, higher price periods. Moreover, in the case of Program 2, the net benefits are probably mis-stated since the largest deficiency payments would have occurred in the last three quarters of the period analyzed and would have resulted in increased supplies, and presumably greater benefits, during later 1974 and 1975. On the other hand, the import restrictions on Canadian pork which were enacted by the U.S. Government in October of 1974 might have caused a depressing effect on Canadian market prices during this period since access to the U.S. market is limited.

Comparison of the Stabilizing Effects of the Price and Margin Deficiency Programs

One point that has never been made clear by the Government of Canada in embarking on a stabilization policy is, what is to be stabilized? The objective could be to stabilize prices received by producers, supply, gross revenue or gross margin.[11/] The two programs analyzed in this paper have substantially different implications for achieving these alternative objectives.

To show this, we present in Table 2, the means ($\bar{X}$) of each of the

variables mentioned above over the period analyzed and the standard deviations (S) of the percentage change in each variable in the same quarter one year apart with each program and no program. An example may help explain this. In order to compute (S) for prices received with no program, a distribution was found by calculating the percentage change in price between the second quarter of 1963 and the second quarter of 1964, the third quarter of 1963 and the fourth quarter of 1964, and so on. Then the standard deviation was calculated as a measure of variability. Four quarter percentage changes are used to avoid fluctuations resulting from seasonal factors.

As would be expected from the foregoing, both programs would have resulted in increased mean values of all four variables and the margin deficiency program would have increased the means of all variables but supply by greater amounts. Examination of the standard deviations indicates that Program 1 would have had a greater stabilizing effect on prices while the opposite is true for pork supply. Program 1 would have reduced the variation in gross revenue, while Program 2 would have resulted in a marginal increase in variation.

Both programs would have resulted in substantial reductions in the variation of gross margin. But the margin deficiency program would have reduced the variation by a greater percentage.

The stabilizing effects of the two programs are clearly different. It is our feeling that the most important variable to stabilize is gross margin. This is particularly true given the recent extreme variability that has arisen in the feed grain sector - and that which is likely to occur in the foreseeable future. If the objective of a stabilization program is to provide a more certain basis upon which producers make decisions, the evidence presented here indicates that a program which bases deficiency payments on fluctuations in

costs and price, as the margin deficiency program does, may be the better approach since it appears to result in less variation in gross margin and in supply.

Summary and Conclusions

This paper has shown that theoretically, a stabilization program based on deficiency payments when prices are exogenously determined can result in economic benefits to society which exceed the tax costs. The theoretical result was confirmed by analyzing the repercussions of two alternative approaches (price deficiency and margin deficiency program) to stabilization of the Canadian pork sector over an eleven year period. The analysis shows that both programs would have resulted in additions to gross revenue and gross margin which were greater than the tax costs of the program.

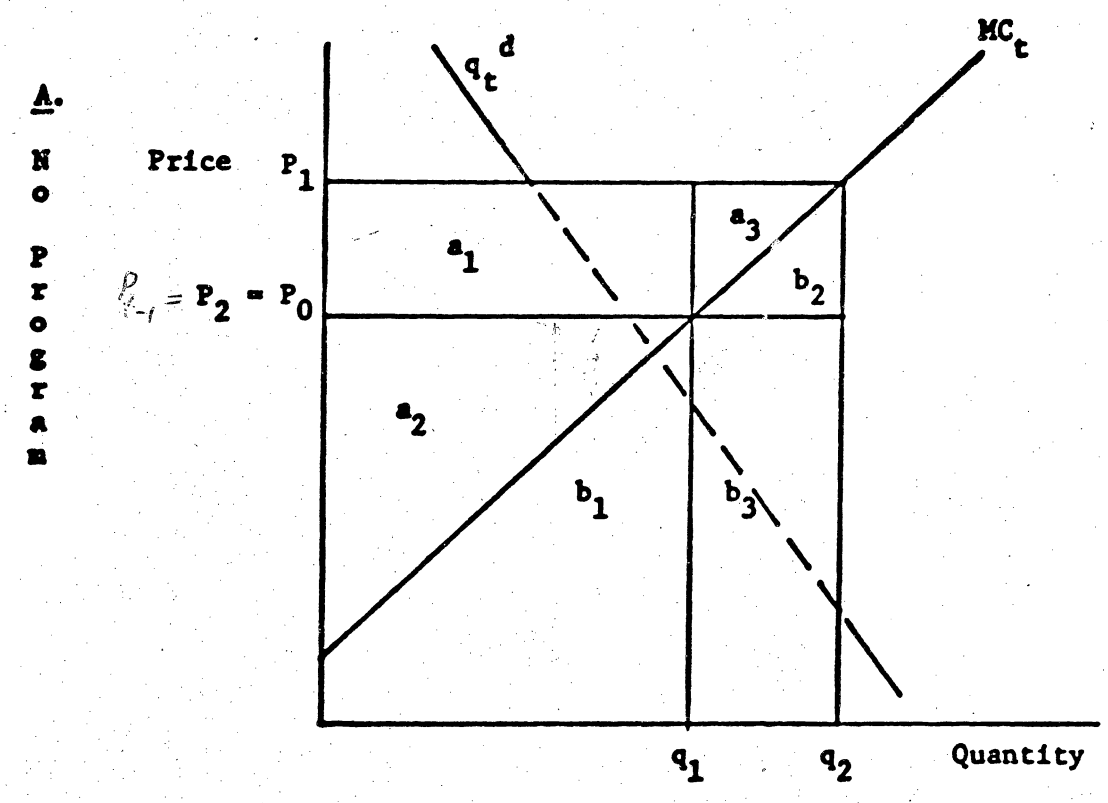
A third conclusion relates to the stabilizing effects of the alternative approaches. Each approach has substantially different stabilizing effects on a number of variables. The margin deficiency approach would have resulted in greater stability of both pork supply and gross margin. Hence it can be concluded that a margin deficiency program is advantageous in an industry, like the pork industry, in which changes in producers' net incomes depend on changes in both final product and input prices.

There is one shortcoming of the analysis which should be noted. One would expect that if a stabilization program is effective in reducing instability and, therefore, uncertainty, there could be a positive supply response to the reduced uncertainty. With uncertainty, producers tend to diversify their operations, and the level of investment is affected by internal and external capital rationing. When uncertainty is reduced, these factors may become less important and supplies may be increased for a given price level (Blandford and

Currie). The model used for our analysis cannot measure the response to reduced uncertainty which could result from the programs analyzed here. With increasing government intervention in the market place, it is essential that research be conducted to analyze the sensitivity of supply response to reduced price or income uncertainty. On the other hand, the methodology used in this analysis provides an estimate of the time path of adjustments in short-run equilibrium prices and quantities which arise from a shoch such as a stabilization program.

This analysis suggests that deficiency payment programs could provide a feasible approach to stabilization for relatively small economies producing primary commodities which are traded in unstable world markets.

FIGURE 1: Unstable Prices and Welfare



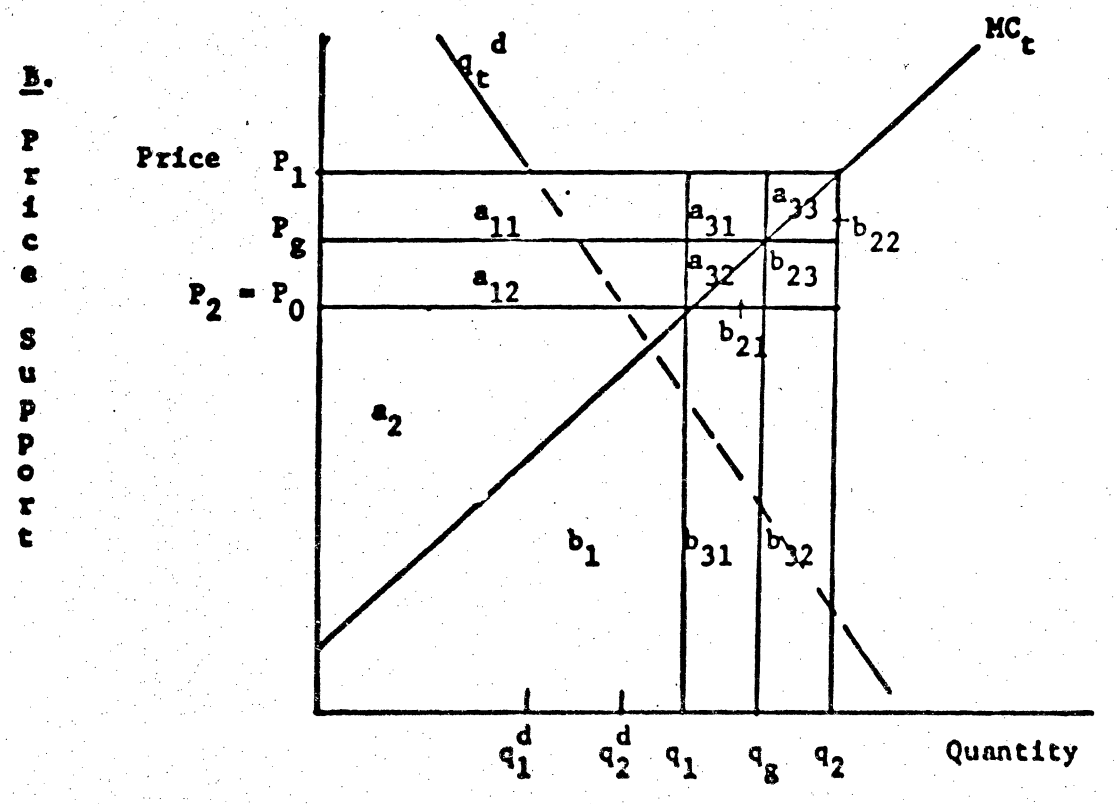


FIGURE 2: Hog Price, Eastern Canada, Programs 1 and 2, 1963-1974 ($/Cwt.)

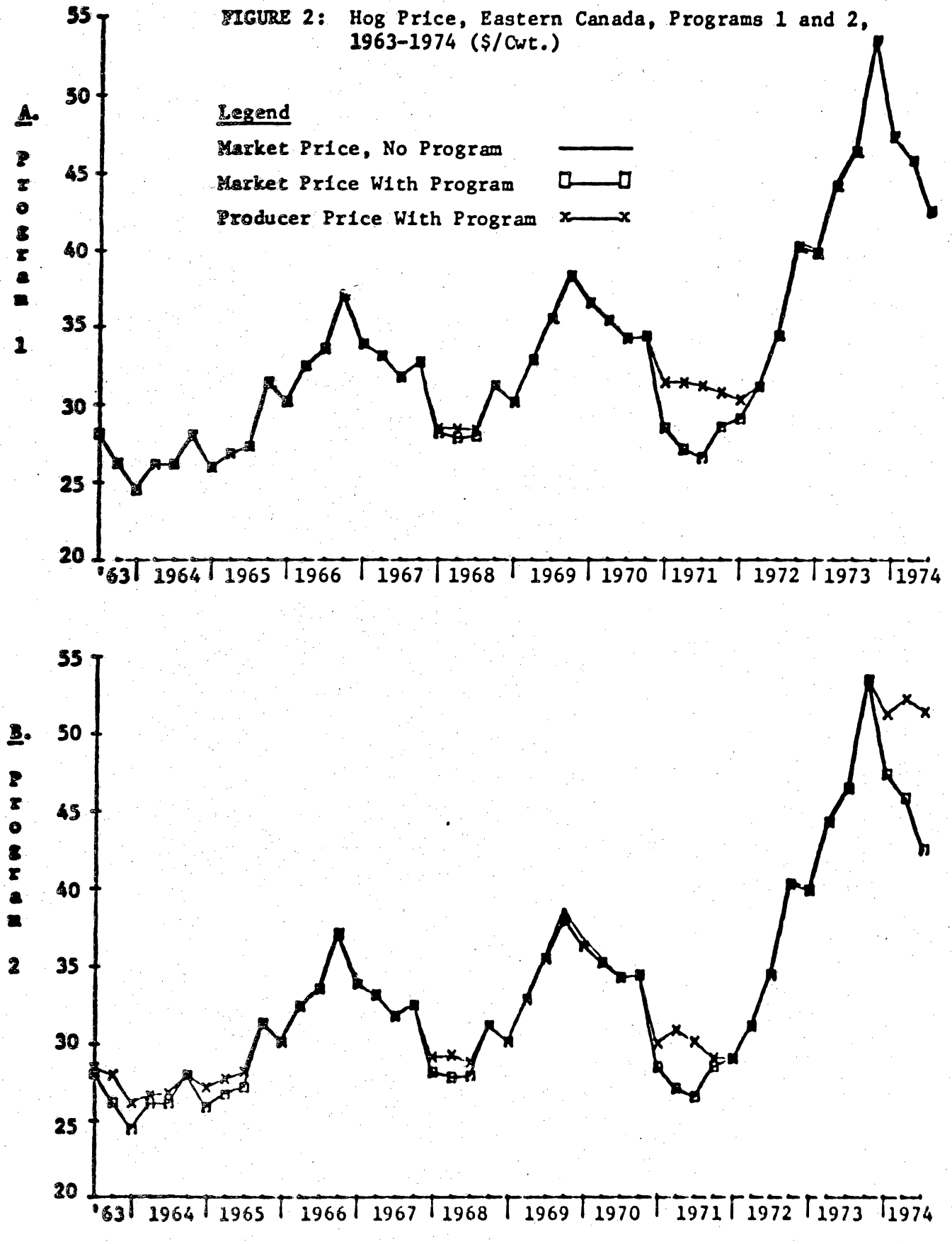


FIGURE 3: Pork Supply, Eastern Canada, Programs 1 and 2, 1963-1974 (Million Cwt.)

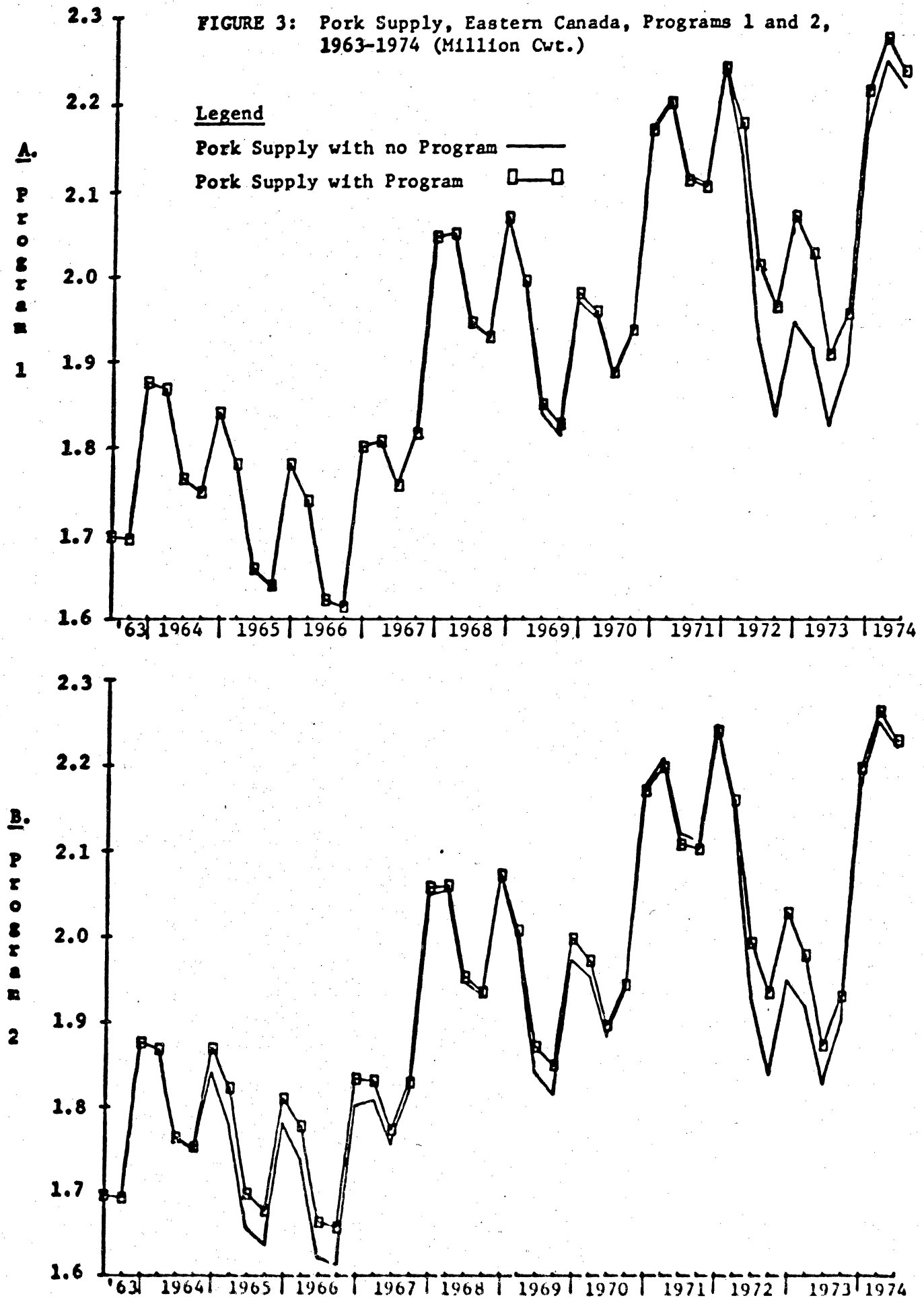
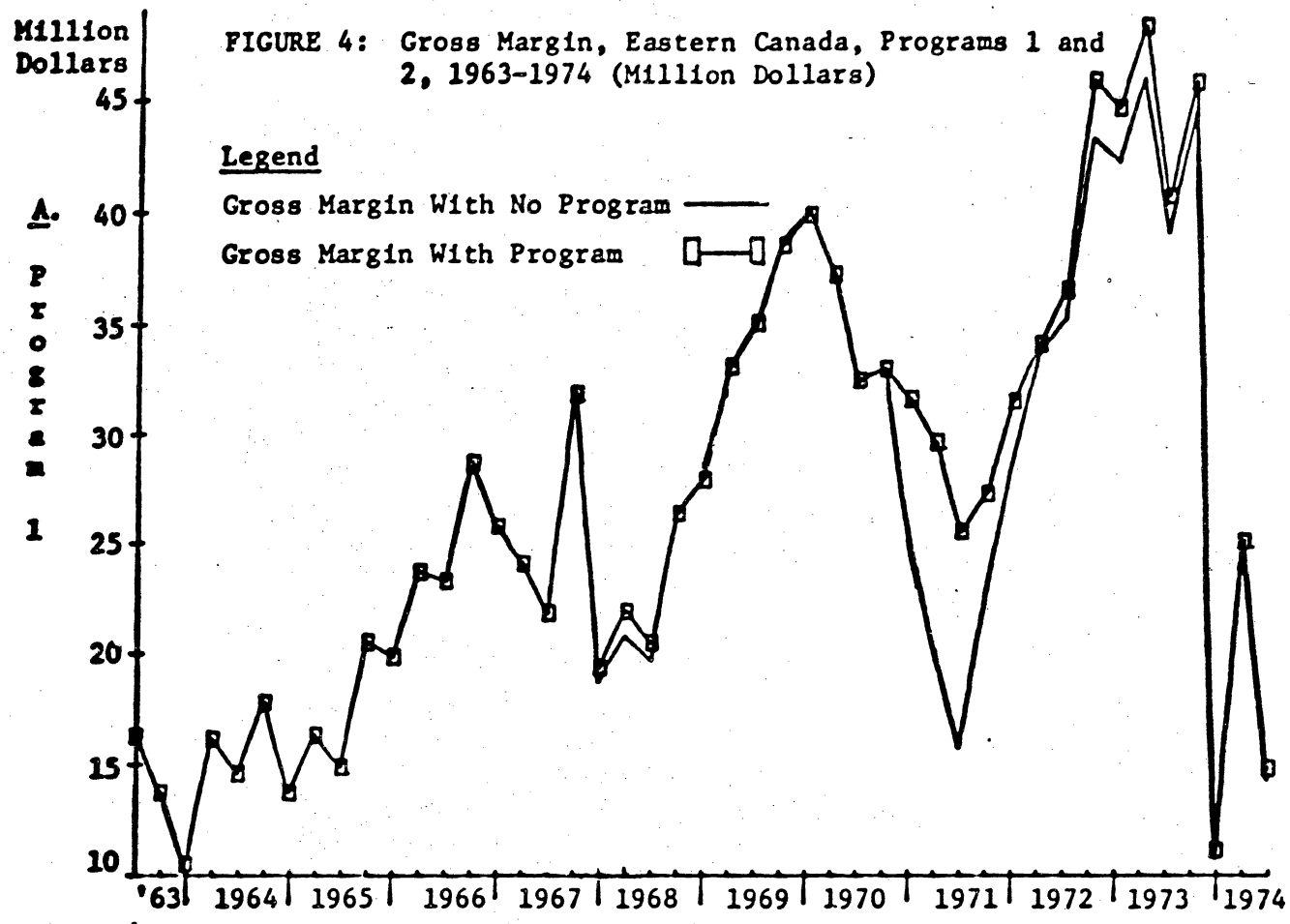


FIGURE 4: Gross Margin, Eastern Canada, Programs 1 and 2, 1963-1974 (Million Dollars)



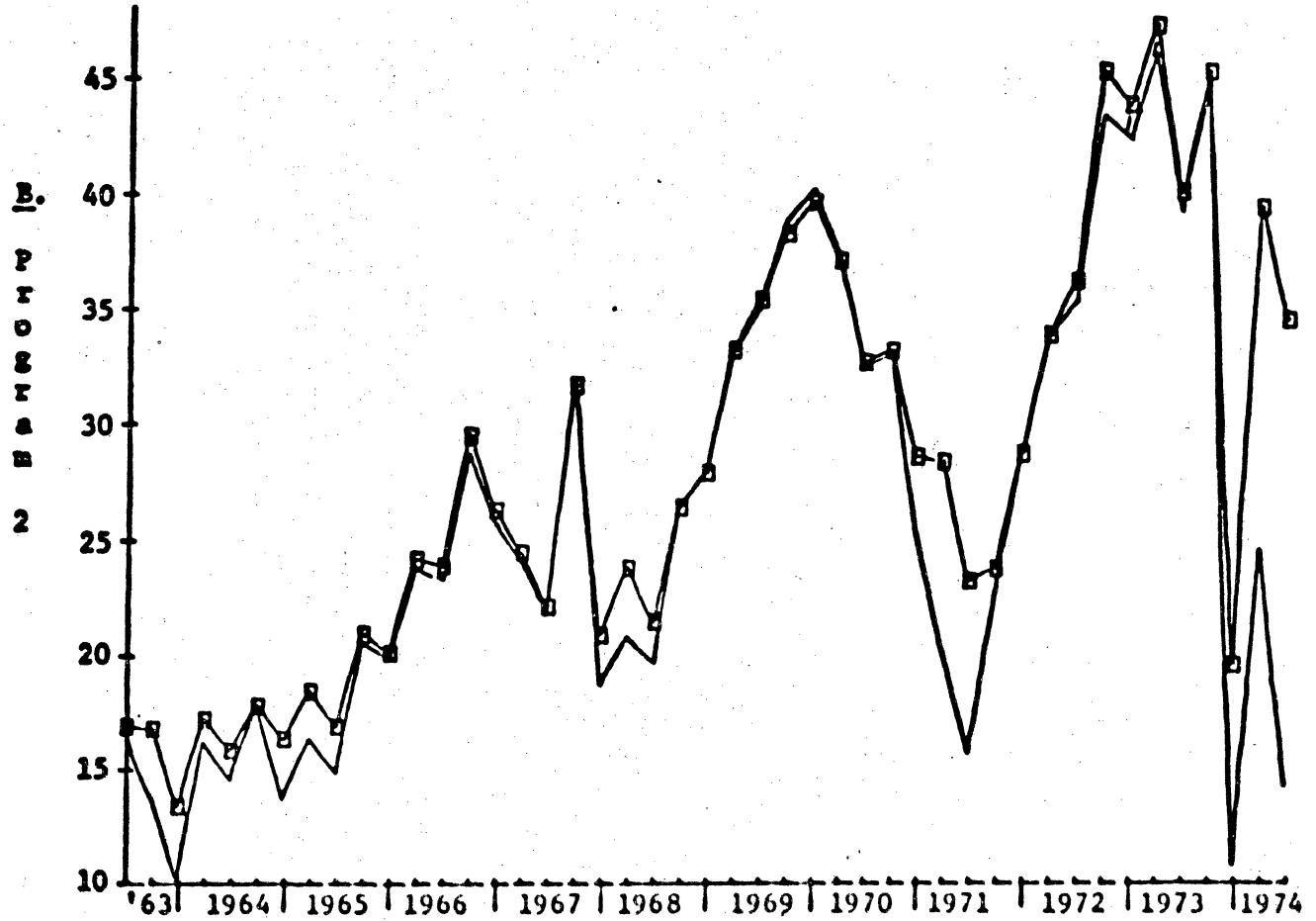


TABLE 1: Tax Costs, Additional Gross Revenue and Additional Gross Margin from Deficiency Payment Program; 1963-1974

	Tax Costs 1963-1974	Gross Revenue 1963-1974	Change in Gross Revenue 1963-1974	Gross Margin 1963-1974	Change in Gross Margin 1963-1974	Change in Net Exports to the United States 1963-1974
	(M. $)	(M. $)	(M. $)	(M. $)	(M. $)	(M. Lbs.)
No Program	--	2,864.1	--	1,254.1	--	--
Price Deficiency Program	36	2,929.4	65.3	1,315.9	61.8	81.4
Margin Deficiency Program	84.6	2,978.6	115.5	1,351.4	97.3	96.3

TABLE 2: Means ($\bar{X}$) of Prices Received, Pork Supply, Gross Revenue and Gross Margin, With No Program and Programs 1 and 2, 1963-1974, and Standard Deviations of Four Quarter Percentage Changes, Eastern Canada

	$\bar{X}$	S
Prices Received		
No Program	$33.23	18.30%
Price Deficiency Program	33.57	15.77
Margin Deficiency Program	34.06	16.30
Pork Supply		
No Program	1.91 (M. Cwt.)	8.52
Price Deficiency Program	1.93	7.11
Margin Deficiency Program	1.93	6.97
Gross Revenue		
No Program	$63.65 (Million)	12.71
Price Deficiency Program	65.10	10.90
Margin Deficiency Program	66.19	12.94
Gross Margin		
No Program	$27.88 (Million)	39.42
Price Deficiency Program	28.97	31.62
Margin Deficiency Program	30.03	27.79

FOOTNOTES

1/ During 1974-75 each country has imposed restrictions on imports from the other. We assume that such restrictions are short-run in nature.

2/ It should be emphasized that costs are a function of the planned level of output and that this level cannot be adjusted instantaneously to price change.

3/ The superscript on q_t has been dropped for convenience. In what follows, q_t^d is not relevant since consumer surplus is not altered by the deficiency payment program.

4/ Since β_0 is the slope of the short run marginal cost function, $\beta_0 = (P_0 - \beta_1)/q_1$. Therefore $1/2\ \beta_0\ q_1^2 = 1/2\ (P_0 - \beta_1)$, which is the area a_2.

5/ In bill C-50, which is presently being debated in Parliament, support will be established at 90 percent of the relevant series. However, the bill allows for voluntary top loading by the Provinces. Therefore, the level of support is set at 95 percent in the programs illustrated here.

6/ The support margin in our case is calculated as 95 percent of the average difference between the price per hundred pounds of pork (carcass wt.) and the cost of feed per hundred pounds of pork (assuming 800 lbs. of feed/hog).

7/ Since there are two Canadian regions in the model, the price or margin is a weighted average of price or margin in Eastern and Western Canada at Toronto and Calgary, respectively.

8/ Gross margin is defined as gross revenue minus feed cost.

9/ Using the formula $\varepsilon_I = \varepsilon_D \frac{D}{I} - \varepsilon_S \frac{S}{I}$ from Orcutt, where ε_I is the elasticity of U.S. import demand from Canada, ε_D and ε_S are the demand and supply

elasticities in the U.S., D and S are the demand and supply levels in the U.S. and I is the level of imports from Canada, the elasticity of import demand in the U.S. from Canada is approximately 200!

10/ Gross margin in any quarter t is based on feed prices in t-1 on the assumption that most of the feed used to grow and finish a hog is fed during the quarter immediately preceeding the one in which the hog is marketed.

11/ In this case, gross margin is used as a proxy for net income.

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