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Price Supports Versus Direct Subsidies: A Simulation Test Of The Federal Dairy Support Program, 1969-72

Ronald Guy Wirick

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PRICE SUPPORTS VERSUS DIRECT SUBSIDIES:
A SIMULATION TEST OF THE FEDERAL DAIRY SUPPORT PROGRAM,
1969-72

by
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Department of Economics

Submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy

Faculty of Graduate Studies
The University of Western Ontario
London, Ontario
June, 1978

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A SIMULATION TEST OF THE FEDERAL DAIRY SUPPORT PROGRAM,
1969-72

ABSTRACT

The Canadian Government supports the income of industrial milk producers through a variety of different policy instruments, including price supports, direct subsidies, and import controls. The relative economic efficiency of these mechanisms for the years 1969-72 is compared on the assumption that (for social and economic adjustment reasons) income to producers is maintained at the historically observed levels. Relative efficiency is measured by applying consumer surplus analysis to gauge the gains and losses of each of the affected groups (producers, processors, taxpayers, and consumers).

Specifically, the thesis first develops a simple theoretical model to examine the relative effectiveness of a pure price support and a pure direct subsidy system. The main conclusions of this initial inquiry are that a direct subsidy system is more efficient than a price support scheme and that consumer welfare will always be higher under direct subsidies.

To test the validity of these conclusions and to gauge the actual magnitude of the efficiency benefits (as well as the gains and losses to each of the affected groups), an econometric model of the industrial milk industry is developed. The model is estimated with time series data from 1958-71 and consists of

nine stochastic and nine deterministic equations divided into three sub-sectors: production, processing, and final demand.

Using this model, polar price support and direct subsidy schemes are then simulated for each of three fiscal years: 1969-70, 1970-71, and 1971-72. The resulting price/quantity vectors are then explicitly compared to the figures which occurred under the actual mixed support scheme. After considering the applicability of consumer surplus analysis in the multi-market case, an explicit comparison is made of the economic benefits accruing to each group and the net welfare effect for the three support schemes. In addition some empirical analysis is devoted to the option of removing all import controls.

The results of these calculations are that the direct subsidy system is substantively more efficient than the price support approach, with an average welfare gain of approximately \$33 million in constant 1961 dollars. The advantage over the actual mixed system is much smaller, averaging about \$6 million. Removing import barriers should further improve efficiency (although this conclusion should be considered tentative because of the major structural adjustments that would result from such a policy change).

One further conclusion of the analysis is that under some circumstances the removal of price supports actually can lead to a decrease in consumer welfare. This surprising outcome is the result of (a) the peculiar structural complications of the dairy market and (b) the particular array of export prices which prevailed in two of the three simulated years.

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Many helpful suggestions and critical comments have been received both on the present paper and on various earlier versions. It is not possible to acknowledge all the individuals who have so contributed. However, I must single out two who have been especially helpful to me in my efforts. Edward Dunnett, formerly of the Secretariat, assisted me in earlier work on the dairy industry and was an invaluable aid in commenting on the present analysis. On many occasions he freely gave of his time and contributed significantly to the development of my thinking. I would also like to add a special word of thanks to my thesis Advisor at the University of Western Ontario, Thomas J. Courchene. His patience in face of seemingly endless delays and his insistence that the work be carried forward have quite literally been invaluable. Naturally, all errors of either omission or commission which remain are solely my own responsibility.

Finally, I wish to thank my wife, Cathy, for her continual

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1. INTRODUCTION.

The present paper provides an economic analysis of the Federal Dairy Support Program which employs a variety of policy instruments (price supports, direct subsidies, quotas, import controls) to achieve its goals. The object of the analysis is to evaluate, in as empirically specific terms as possible, the efficiency of the actual system as compared to alternative schemes employing different program mixes. For several reasons dairy policy represents an excellent opportunity to attempt this kind of comprehensive policy analysis:

(1) The support program has been one of the more significant market-intervention activities of the Federal Government. For the period of time covered by the analysis (1969-72) budgetary costs averaged in excess of \$100 million per year, and currently they are more than three times this high. Indeed the dependency of the dairy industry upon support is probably as great as any other sector of the economy.

(2) The theoretical analysis of the idealized market situation is relatively straightforward, and the conclusions are unambiguous. Yet the actual market structure is quite complex, the relevant behavioral relationships are not always clear, and the specific application of theory is sometimes quite difficult.

(3) All the alternative policy options (price supports, direct subsidies, import controls) actually have been used by the Federal Government. This permits much more accurate simulation of

differing policy mixes, as it is possible to actually observe the functioning of the various institutional mechanisms.

(4) Relatively detailed industry data are available, and although in some instances their accuracy are open to question, the general breadth of coverage and reliability compare favourably with any other industry-specific data base. This detail is essential to the estimation of the empirical impact of alternative policy options.

Chapter 2 of this paper describes the institutional structure of the Canadian dairy industry and of the present support system. Chapter 3 outlines the general nature of the problem being analyzed, the alternative policies to be considered, and the criteria to be used for comparing these policies. The theoretical model and its conclusions are developed in Chapter 4. Chapter 5 presents a detailed description of an econometric model of the industrial dairy industry. This model is then employed in Chapter 6 to calculate the empirical effects of the alternative systems. Finally, the results of the analysis and concluding remarks are given in Chapter 7.

It should be noted that although there are many similarities in both circumstances and nature between the Federal Dairy Support Program as analyzed in the simulation period and the program as it is currently operated, there are also many differences. The differences are large enough to preclude any straightforward extension of the empirical analysis to the most recent time period. In particular the chief problem is that some of the structural assumptions underlying the econometric model, while generally valid during the

estimation period (1958-71), are considerably less accurate during the last several years. Some of these changes are cited, where appropriate, in the body of the report. In addition, Appendix II briefly addresses the question of to what extent the policy conclusions of the present paper can be used to draw useful inferences about the current dairy support program.

2. DESCRIPTION OF THE INSTITUTIONAL SETTING

2.1 Production of Milk

The set of milk producers in Canada can basically be divided into two groups: one group produces fluid milk which is sold for direct human consumption as whole or partially skimmed milk, while the other produces industrial milk which is sold as an input into manufactured dairy products such as butter, ice cream, cheese and skim milk powder. The present study is concerned exclusively with the policies affecting the industrial milk market. However, to fully understand the descriptions and analysis which follow, it is necessary to have some appreciation of the relationship between the two milk sectors.

Industrial and fluid milk producers were originally separated because of product quality differences, as fluid producers had to satisfy more rigorous hygienic standards than their industrial counterparts. Although relative improvements in industrial milk have now virtually eliminated these quality differences, the two markets remain separated by institutional constraints. A farmer can only ship milk to the fluid market if he possesses a fluid quota issued by his provincial market board. Since the aggregate quota amount is fixed at any point in time, this policy effectively insulates the fluid market from its industrial counterpart. The converse, however, is

not true. Although the industrial market also has quota controls (described in the following sections), for the period covered by the study there was no direct restriction on industrial milk sales; fluid producers could "dump" their residual production on the industrial market.

This asymmetric separation of the two markets has entitled fluid milk producers to a position of affluence which is not shared by industrial producers. In general, the output of fluid farms is larger, enabling fluid operators to take advantage of the economies of large-scale production. Furthermore, the price of fluid milk is much higher than the price of industrial milk. For example, in 1971 (the last full year covered by the study) the average price of fluid milk was \$6.51 per hundredweight while the average price of industrial milk was only \$4.72 for the same quantity.¹

¹Statistics Canada, Dairy Statistics, 1971 (23-201). To be perfectly fair, it should also be noted that fluid producers must produce a specified minimum amount of milk every day throughout the year. As production is seasonal by nature, this constraint raises the effective cost of fluid milk. Nevertheless in 1973 fluid quotas had a sizeable market price--\$1,500 per hundredweight of daily milk in Ontario according to V. McCormick ("Milk Quotas What Do They Mean?" Canadian Farm Economics, October, 1973, p. 27). More recent studies also confirm that fluid quota values can be very high. For example, in Ontario quota values in 1976 are reported to have reached \$3,000 per daily hundredweight (Broadwith, Hughes, and Associates, "The Ontario Milk Marketing Board: An Economic Analysis" in Government Regulation, Ontario Economic Council, 1978, p. 95). This would imply that the price differential between industrial and fluid milk is at least partially a monopoly rent.

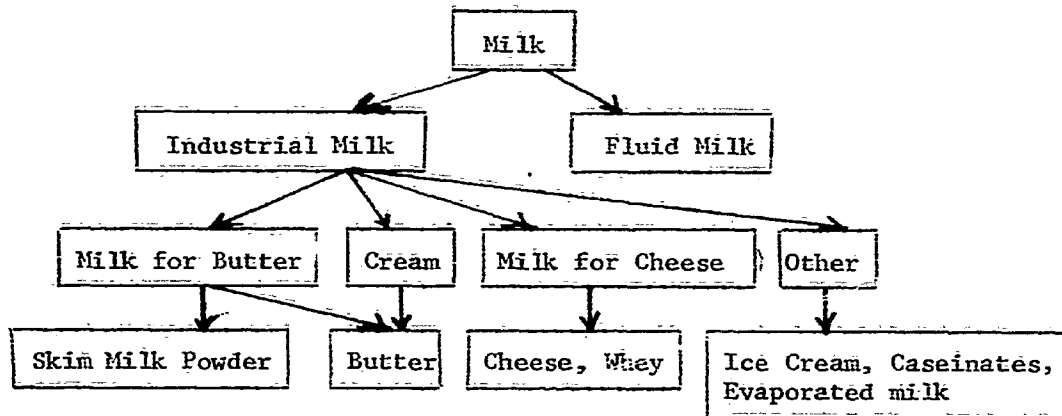
2.2 Processing of Industrial Milk

Despite the wide variety of goods which can be made from industrial milk, the processing sector consists of highly specialized butter and cheese firms as well as multi-product plants. The specialist creameries depend on producers to separate the cream from whole milk. (The skim milk residual is retained by farmers for use as a substitute feed for their livestock.) The multi-product plants, on the other hand, take advantage of the "joint-product" nature of milk processing. These firms buy milk from the farms and skim it themselves, converting the cream into butter and the skim milk into skim milk powder. They may also manufacture cheese (and its by-product whey), ice cream, evaporated milk and other products within the same plant. During the late 1960's and early 1970's these multi-product firms have captured a larger portion of the processing industry. This shift probably reflects a number of factors including increased willingness of most milk producers to ship whole milk and not cream under the circumstances which have recently prevailed.¹

¹The gradual elimination or minimization of differential transportation charges in the pricing practices of provincial milk marketing boards also may have contributed to the expansion of large multi-product plants at the expense of small specialized firms. Easy farm accessibility (and hence low transportation costs), had been about the only economic advantage the small plants possessed. See Broadwith, Hughes and Associates, op. cit., pp. 93-94, 101.

The anatomy of the dairy industry is depicted in Figure 1:

Figure 1



The relative magnitudes of these flows can be summarized as follows: of the 16.3 billion pounds of milk produced in 1971, 32.4% went to the fluid milk market. Of the 11.0 billion pounds of industrial milk and cream, 60.9% was shipped as milk for butter and skim milk powder, 25.2% as milk for cheese, and 13.9% as milk for other manufacturing uses.¹

¹Derived from Dairy Statistics, op. cit., 1971. It should be noted that the schematic representation of Figure 1 is not completely accurate. A portion of fluid milk shipments is eventually sold as partially or fully skimmed (fluid) milk. The cream which is skimmed off is generally sold as other fluid milk products (e.g., whipping cream, cereal cream, "half and half", etc.); however some of it is used to produce industrial milk products such as ice cream or butter. This overflow tends to weaken the assumption that the two markets are quite separate. During the estimation period (1958-71) this was not a major factor, as the overflow was small. However, there has been a significant increase in its relative importance during the 1970s. For example, skimmed milk represented just 14% of total fluid shipments in

There were 18,000 fluid producers and 93,000 industrial milk producers in 1971.¹ If a commercial farm is defined as one having total sales in excess of \$5,000 in a year, then of these approximate 111,000 dairy producers only 44,000 could be considered commercial farmers.²

2.3 Federal-Provincial Jurisdictions

As both the federal and the provincial governments are presently committed to the dairy industry, it is important to outline their respective jurisdictions before considering the details of their involvement. The British North America Act of 1867 did entitle both provincial and federal governments to conduct agricultural assistance programs but left the question of legislative jurisdictions open to question. Although the BNA Act appears to guarantee the primacy of all federal legislation relating to agriculture, recent high court decisions have established that commercial transactions in agricultural products within a province do not come under the constitutional category of agriculture, but are a matter of property and civil rights, which the British North America Act specifically reserves to the provinces.

1965 (and only 4% of all milk shipped), but by 1974 skimmed milk accounts for 41% of fluid shipments. (Food Prices Review Board, Dairy Foods I: Prices, December, 1975, Table 2, p. 7.)

¹D. L. McFarlane and L. A. Fischer, Canadian Dairy Industry: Short-Term Prospects, a report to the Food Prices Review Board, March, 1974, p. 29.

²Statistics Canada, Census of Canada, 1971, Vol. IV, Agriculture.

In practice, federal-provincial jurisdictions have been delineated traditionally by a de facto separation of the milk producing industry into fluid and non-fluid producers. The provincial governments control the fluid producers, while the federal government has prime responsibility for industrial milk farmers. The provincial milk marketing boards (with the explicit or implicit approval of their provincial governments) have limited the supply of fluid milk by issuing quotas to all fluid producers and by paying fluid prices only on milk covered by provincial quota. As noted previously, the rigour of the fluid-quota policy has allowed fluid producers to receive a higher price for their milk than their industrial counterparts, whose product has been less rigidly managed by federal agencies. The federal agency which is primarily responsible for conducting the national dairy policy is the Canadian Dairy Commission (hereafter the CDC).

In December 1970, the de facto jurisdictions became more poorly defined. At that time, the CDC authorized the provincial milk marketing boards to issue market share quotas to all producers of industrial milk and cream in Ontario and Quebec. Provincial governments became more involved in affairs relating to the industrial milk market but did not inherit control of the market share quota system. Matters relating to enforcement of the system or to changes in quota policy are jointly managed both by the CDC and the marketing boards, with the pre-eminent role played by the CDC.

2.4 The Canadian Dairy Commission

On 11th July, 1966, the Canadian Dairy Commission was established by an Act of Parliament with powers to pursue specified objectives:

The objects of the Commission are to provide efficient producers of milk and cream with the opportunity of obtaining a fair return for their labour and investment and to provide consumers of dairy products with a continuous and adequate supply of dairy products of high quality.¹

The Act entitled the CDC in pursuit of these objectives to purchase any dairy product and to dispose of such products in any manner seen fit, to make payments to producers of milk and cream, to investigate any matter relating to the costs of production of any dairy product, and to assist in the promotion and improvement of dairy products in general.

The CDC was originally established because the price of industrial milk was considered to be too low to allow efficient producers a "fair return". The CDC has used a variety of techniques to remedy this situation. The CDC has taken advantage of the Export and Import Permits Act which controls imports of dairy products such as butter, skim milk powder and cheddar cheese in support of national policy.² It has instituted a mixed support policy combining a system of price

¹Canadian Dairy Commission Act, Section 8.

²See Export and Import Permits Act, Section 5, for details.

supports with a scheme of direct subsidy payments to producers of milk and cream. Each year, the CDC announces the support prices of butter, cheese, skim milk powder and other dairy products, and also indicates its willingness to purchase, at the support prices, domestic supplies of these products which cannot be sold to private consumers. By raising the prices of final dairy products above marketing clearing levels, the CDC can indirectly bring about an increase in the price of industrial milk itself. The CDC then disposes of any accumulated stocks of dairy products by selling them (often at a loss) in the international market.

In addition to implementing the price-support system (for the period covered in the current study), the CDC issued subsidy eligibility quotas (SEQ) based on previous output levels, to milk and cream producers, entitling holders of the quotas to a CDC subsidy payment for every hundredweight of milk or cream shipped up to the quota limit. The SEQ did not act as a direct constraint on total production. It was possible for a farmer to produce and sell milk or cream in excess of his SEQ, or even without an SEQ. These over-quota and non-quota sales, however, did not receive subsidy payments.

In addition to its three major controls (price supports, import controls, and direct subsidies), the CDC has employed several other policy instruments. Chief of these have been levies (or holdbacks) on quota production and penalties on production in excess of SEQ production. The levies were deducted from the gross subsidy payments; their magnitude was supposed to be related to the costs of surplus disposal. The penalties were also designed to help control

disposal costs. Larger penalties were set when the CDC wished to limit milk and cream production, and hence to minimize the accumulation of dairy-product surpluses.

One further policy complication is of importance. A market share quota system (MSQ) was initiated in 1971-72 through an agreement signed between the CDC and the provinces of Ontario and Quebec. The new control has since been accepted by all remaining provinces. The agreement authorized provincial milk marketing boards to issue market share quotas to industrial milk producers in Ontario and Quebec, based on the producer's 1969-70 output level or on his subsidy eligibility quota, whichever was greater. The MSQ, in essence, provides each quota holder with a percentage of total quota production. Total quota production itself is variable and is changed from time to time by the CDC, in cooperation with the respective marketing boards, in an attempt to achieve 'butterfat balance' (balance of demand and supply of dairy products at the support prices chosen by the CDC).

In recent years producers have been given strong incentive to adhere to their market share quotas. A prohibitive penalty has been levied on transactions in excess of MSQ. Similarly a dairy farmer who produces less than a given percentage of his market share quota loses the shortfall from this percentage to other market share quota holders in subsequent years. These underquota and overquota sanctions have given the CDC a considerable amount of control over the total supply of industrial milk in any one year.

For approximately three years from 1971 through 1973 the dual quota systems (SEQ and MSQ) existed simultaneously. Then in 1974 the federal government extended the direct producer subsidy (with some qualifications) to all production covered by the (larger) MSQ, and therefore essentially ended the separate existence of the SEQ system. Since that time the manipulation of a variety of both price and quantity controls within the MSQ system have been used aggressively by the federal government in an explicit attempt to implement a supply management system--that is, to control domestic supply so that it more closely matches domestic demand at the administered levels of producer returns and consumer prices. Any empirical study of this recent period, therefore, would have to explicitly account for the effect of MSQ system on both producer and processor behavior. For the period covered by the present study, however, the MSQ system can essentially be ignored.¹

The magnitude of the federal dairy assistance program is summarized in Table 1 which lists the budgetary expenditures of the CDC from its inception in 1966 through 1971-72, the last year of the simulation period.

¹The implications of the development of the supply management system are outlined in Appendix II.

TABLE 1
 Expenditures by the Canadian Dairy Commission
 (in millions of dollars)

Expenditures	1967-1968	1968-1969	1969-1970	1970-1971	1971-1972
A. Direct subsidy payments (net)	96.6	100.8	82.6	74.0	92.2
B. Phase-out payments	...	4.4
C. Cost of Price Support Operations	10.0	35.5	64.3	37.9	9.2
D. Administrative and misc. costs	.2	.3	.4	.9	1.0
TOTAL	106.9	141.0	147.3	112.8	102.4

Source: CDC Annual Reports

3. STATEMENT OF THE PROBLEM

The dual legislated objectives of the CDC are to provide a fair return to efficient producers and an adequate supply to consumers. Despite the ambiguity of both these goals, it is clear from the subsequent evolution of CDC policies that the primary purpose of the federal dairy support program has been to raise producer returns above the free-market level. Two plausible arguments, one economic and one social, could be made to justify such intervention. The economic rationale rests upon the declining demand facing dairy farmers since World War II. Primarily caused by the growing acceptance of margarine as a butter substitute, this shift in demand led to depressed milk prices, since trend levels of production could not clear the market at a "normal" price level. Eventually market forces themselves would dictate a solution. The low rates of return in the industry would discourage some producers from dairy farming and the resulting production decline would raise prices. The process would continue until rates of return in dairy farming were roughly equivalent to those in any other endeavour.

The difficulty with this laissez-faire adjustment mechanism is two fold: the process may take an unacceptable long period of time and the burden of adjustment would fall predominantly upon those "squeezed out" of the industry. The first of these factors is important because during the (possibly extended) period of disequilibrium the returns to all producers will be low--from the viewpoint of the CDC's objectives, efficient producers will not receive a fair rate of return. The dislocation costs of farmers displaced during adjustment could also be significant for there is no guarantee that these individuals and their families would be able to make an easy transition into another field of employment. For both these reasons then the government may choose to intervene.

The second argument for government aid is based upon the social goal of maintaining a viable rural society. In the last several decades immense technological changes have occurred in the optimal methods of milk production. Many of these changes, however, can only be adopted by the larger producers as the capital investment necessary for their implementation is too "lumpy" for use at lower production levels. It is therefore conceivable that after adjustment takes place only the largest, most efficient farmers will remain in the industry.

In particular it is possible that the family farm will no longer be a viable production unit, even if the farmer uses the best production methods available for his farm size. In such a case society as a whole may decide that the market-dictated solution is unacceptable, and that rural life must be maintained even at the cost of indefinite aid to the industry. The goal then would be to assure a fair return to efficient, family-farm producers.¹

If either of these two arguments--the costs of disequilibrium adjustment and the social value of family farming--is accepted by policy makers, then a dairy support program of some type is an obvious corollary. The next logical questions to ask are what level of aid should be given and over what time period should it be offered? The present study makes no attempt to solve either of these, essentially long-term problems. Not only are both issues exceedingly complex analytically--involving difficult questions about dynamic production behaviour--but many of their aspects are essentially normative. A final decision, therefore, will probably be made as much on the basis of collective value judgements than on "objective" analysis. However, given that the overall level and timing of aid is socially determined, a decision must still be made as to what mix of policies should be

¹There are certainly several problems involved in choosing an appropriate definition of a family farm. Obviously, the scale of feasible production by a family farm operator employing some hired labour would be different from the possible output of a farmer employing the resources only of his immediate family. Ultimately, an arbitrary definition must be made and the level of aid set to sustain this type of family farm.

used to maintain this support. It is this issue with which the present paper is primarily concerned.

Specifically, the problem can be phrased in the following manner. If returns to the legislated interest group (producers) are kept at the same level as occurred under the actual CDC support scheme, can this aid be supplied via an alternative system in a more economically efficient manner? To make this question operationally useful, some further clarification of terms is necessary:

(1) Producer returns is interpreted as returns to (subsidy eligibility) quota production. There are two reasons for this definition. First, at the inception of the CDC, subsidy quotas were allocated to virtually all industrial milk producers on the basis of their previous production levels. SEQ production, therefore, can be considered the primary industrial milk supply. Second, a very large proportion of the production not covered by subsidy quota is the residual milk and cream of fluid producers. A strong argument can be made that these farmers are more than adequately "protected" by other (chiefly provincial) programs.¹

(2) The measurement of economic efficiency is relatively straightforward and involves an application of the compensation principle. With returns on quota production held constant, the market

¹ Cf. the discussion about fluid producers in Chapter 2.

impact of switching to some other support system can be estimated. It is then possible to calculate the resultant gains and losses to all other affected groups (non-quota producers, processors, consumers, and tax payers). The sum of the group effects is the net benefit; if it is positive (negative), then the policy change would lead to an overall gain (loss) in efficiency.

(3) The explicit policy alternatives considered are a pure direct-subsidy system and a pure price-support scheme. In addition some analysis is devoted to the question of removing the present structure of import controls. Chapter 4 analyzes the relative theoretical efficiency of price supports and direct subsidies, while Chapters 5 and 6 supply specific empirical comparisons of the two support mechanisms.

4. RELATIVE ECONOMIC EFFICIENCY: A THEORETICAL ANALYSIS

The present chapter employs the theory of consumer/producer surplus to estimate the component gains and losses of switching from a price support to a direct subsidy system, and hence to gauge the net benefit (or efficiency gain) of such a change. The consumer surplus technique, of course, has been the subject of considerable theoretical analysis and criticism.¹ For example, it is often argued that the consumer-surplus technique is only valid if the marginal utility of money is constant. The approach is also criticized as being only a partial equilibrium tool which ignores general equilibrium effects. The inability of consumer surplus to measure income distributional effects is another cause for complaint.

There are two rejoinders to these (and other) objections. First there is the practical problem of selecting an alternative--if consumer surplus is rejected, in what other way can one quantify the effect of price changes upon consumers? Either no judgement of welfare effects

¹The initial specification of the consumer surplus concept is usually attributed to A. Marshall (Principles of Economics, 8th ed., London, 1920) and H. Hotelling ("The General Welfare in Relation to Problems of Taxation and of Railway and Utility Rates," Econometrica, July 1938, pp. 242-69). The concept was refined (and multiplied) by J. R. Hicks ("The Rehabilitation of Consumers' Surplus," Review of Economic Studies, Feb. 1941, pp. 108-16, and "The Four Consumers' Surpluses," Review of Economic Studies, 1943, pp. 31-41). The theoretical underpinnings have been attacked by many including P. A. Samuelson (Foundations of Economic Analysis, Cambridge, 1947, and The Collected Scientific Papers of Paul A. Samuelson, Cambridge, 1965, Chapter 5). More recent work in the field has been quite extensive. Two of the more notable contributions have been made by D. M. Wince ("Consumers' Surplus and the Compensation Principle," American Economic Review, June 1965, pp. 395-423) and A. C. Harberger ("Three Basic Postulates for Applied Welfare Economics: An Interpretive Essay," Journal of Economic Literature, Sept. 1971, pp. 785-797).

can be made at all, or one must rely purely upon intuition. Neither alternative is desirable when practical problems require policy decisions.

Second, the objections themselves are open to criticism. In a recent highly instructive article, A. C. Harberger demonstrated that consumer-surplus analysis is a perfectly valid approach to applied welfare-economics problems, if one is willing to accept three postulates:¹

- (i) The competitive demand price for a given unit measures the value of that unit to the demander;
- (ii) the competitive supply price for a given unit measures the value of that unit to the supplier;
- (iii) when evaluating the net benefits or costs of any program, the costs and benefits accruing to each member of the relevant group should normally be added without regard to the individual(s) to whom they accrue.

These postulates are not ideal, but under most circumstances they should be acceptable.

Reasoning from these three basic assumptions, Harberger demonstrates that many of the objections to the use of consumer surplus are misplaced. He notes, for example, that the use of national income

¹ A. C. Harberger, "Three Basic Postulates for Applied Welfare Economics: An Interpretive Essay," Journal of Economic Literature, Sept. 1971, pp. 785-797. Following a quite different approach, M. E. Burns arrives at conclusions which are quite consistent with Harberger's (cf. M. E. Burns, "A Note on the Concept and Measure of Consumers' Surplus," American Economic Review, June 1973, pp. 335-344.

statistics for both positive and normative purposes is well accepted by applied economists.

"(yet the defects of) consumer surplus analysis hold a fortiori with respect to the measurement of a national income. If we are prepared to more-or-less agree on national income methodology (while being mindful of its defects), why should we resist approaching an agreement on a methodology for applied welfare economics (also keeping its defects in mind, but aware at the same time that they are much less serious than those applying to national income?)"¹

The consumer-surplus approach, therefore, seems quite appropriate for comparing the economic welfare effects of alternative programs. It not only is the sole technique which yields concrete quantifiable answers, but within reasonable limits, it is eminently sound and defensible. This is particularly true for application to the dairy industry since the price and income changes are very small with respect to the remainder of the economy--hence the partial equilibrium limitations of consumer surplus are not very important.

Of course, the theoretical consumer-surplus analysis of this chapter is still limited in its applicability to the actual market situation and attendant government support scheme. In particular the following simplifying assumptions are made:

¹ Ibid., p. 786. Harberger's proof that the assumptions underlying national income methodology are more restrictive than those necessary for consumers' surplus is quite elegant. He uses the Taylor series expansion of a utility function to demonstrate that national income measures incorporate only the first-order term of the expansion, while consumers' surplus uses both first and second order terms. For the mathematical details see pages 787-8 of his article.

(1) Only the polar cases of pure price supports and pure direct subsidies are explicitly analyzed. It will become clear, however, that the actual mixed support scheme is intermediate in efficiency effects to these two extreme systems.

(2) The analysis is restricted to an idealized single-market case. Considering the extreme complexity of the actual, inter-connected dairy market structure, this is a rather restrictive assumption.¹

(3) The only affected groups considered are taxpayers, consumers, and producers--there is no separate processing sector.

(4) The complexities of levies, penalties, and other charges made on producers under the present CDC support scheme are omitted entirely.

(5) The analysis is strictly comparative static--the dynamics of price and quantity adjustment are ignored.

(6) In gauging the impact of the export market, it is assumed that the level of Canadian exports (either autonomous or "dumped" has no effect upon international prices--in other words that Canada is a "small country". The possible consequences of relaxing this postulate are noted at the end of the chapter.

(7) The effect of import controls is not analyzed. The ban on imports is maintained under both systems.²

¹The theoretical extension of the model to the multi-market case is discussed in some detail at the beginning of Chapter 6.

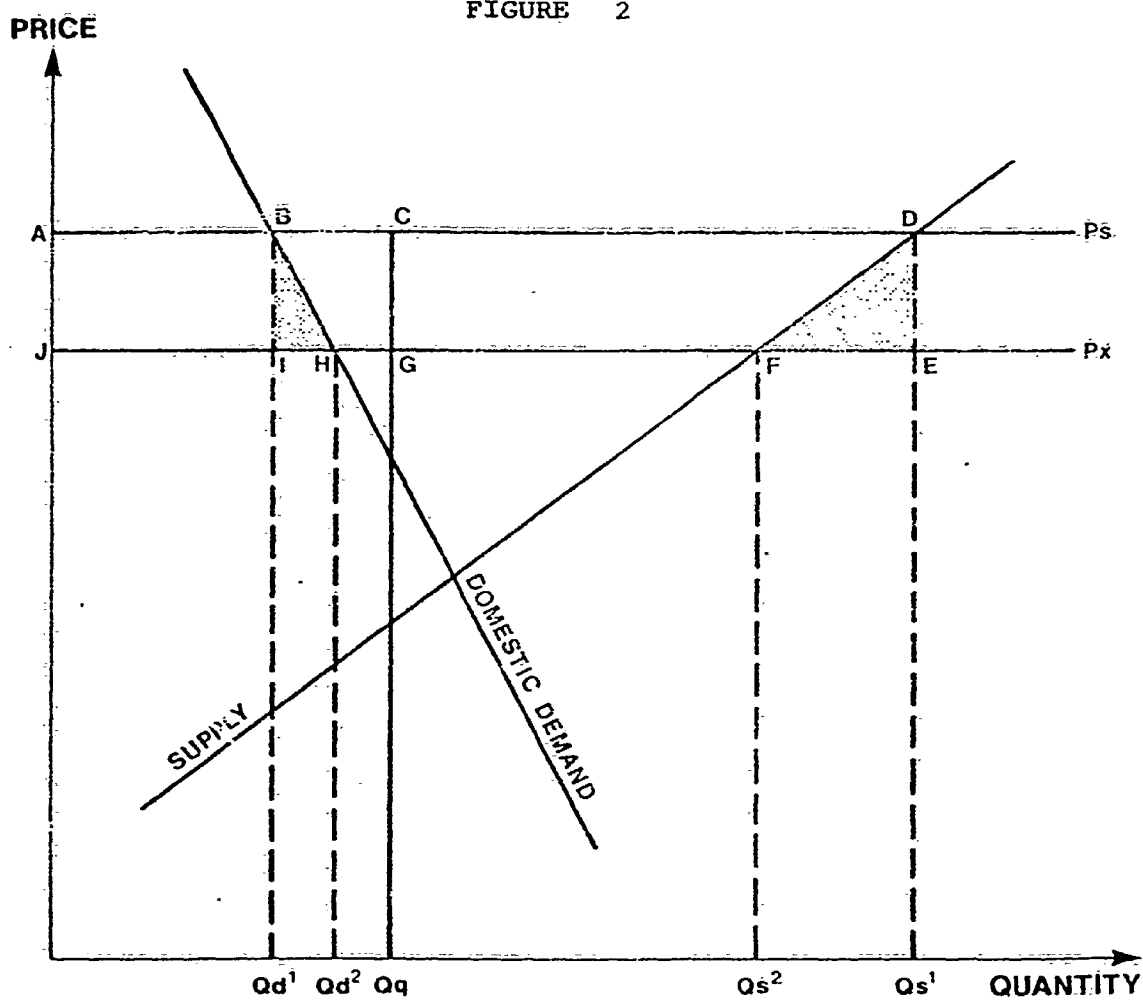
²The same assumption is made in the empirical analysis of Chapter 6. See, however, Section 6.6 for a discussion of this point.

Given the previous assumptions, the basic single-market situation is portrayed in Figure 2. Under both the direct-subsidy and the price support systems the designated "fair return" is P_s . The price-support approach maintains this return to producers through the offer-to-purchase. Domestic demand is then equal to Q_d^1 while total supply is Q_s^1 . Excess supply ($Q_s^1 - Q_d^1$) is purchased by the government (at the price P_s) and dumped on the foreign market for the (exogenous) export price, P_x . The budgetary cost of the program therefore is equal to rectangle BDEI in Figure 2.

Under a direct subsidy scheme aid is provided in quite a different way, as price is allowed to fall to its free-market level. In the diagrammed example with the export price above the domestic clearing level, price drops to P_x . Domestic demand is Q_D^2 , while total production is Q_S^2 . Again the surplus production is exported, but this time without government aid. Instead the government maintains the same return on quota production (Q_q) by paying a per unit subsidy equal to the difference between P_s and P_x . Under this system the quota does not directly restrict production--anyone can produce and sell milk for whatever (free-market) price he can obtain. The quota simply serves to distinguish the original target population of industrial milk farmers from other producers.¹ The cost to the government is equal to the amount of the subsidy times total quota production, or rectangle ACGJ in Figure 2. The direct subsidy program implies an increase in consumer surplus.

¹The allocation of quotas under the actual CDC operation was discussed in Sections 2.3 and 2.4.

FIGURE 2



Consumers purchase a larger quantity (Q_d^2) at a lower price (P_x); the equivalent income gain is equal to trapezoid ABHJ. On the other hand the lower price means that producers experience a loss on production not covered by quota; the decrease in producer surplus is equal to trapezoid CDFG.

The net benefit of switching from a price-support to a direct subsidy system is equal to the sum of the effects upon taxpayers, consumers, and producers:

$$\begin{aligned} \text{Net Benefit} &= \text{Budgetary cost of price supports} - \\ &\quad \text{Budgetary cost of direct subsidies} \\ &\quad + \text{Increase in consumer surplus} \\ &\quad - \text{Decrease in producer surplus} \end{aligned}$$

$$\text{or Net Benefit} = \text{rec. BDEI} - \text{rec. ACGH} + \text{trap. ABHJ} - \text{trap. CDFG}$$

$$\begin{aligned} \therefore \text{Net Benefit} &= \text{triangle BHI} + \text{triangle DEF} \\ &= \text{shaded area in Figure 2} \end{aligned}$$

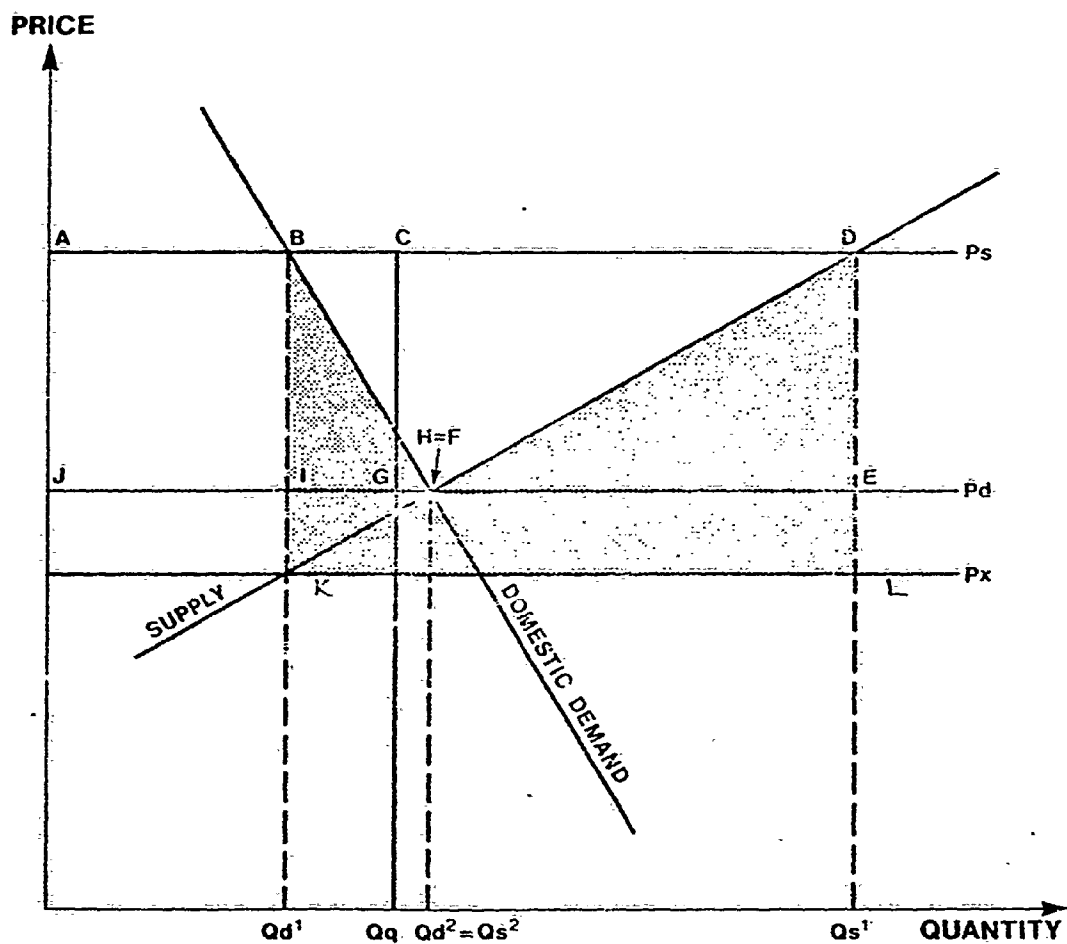
Even from this simple derivation it is easy to see that the net benefit is always positive--i.e., direct subsidies are always more efficient than price supports.¹ It should be noted that an efficiency gain exists regardless of (1) the particular shapes of the demand and supply curves, or (2) the magnitude of the export price. These factors do affect, however, both the magnitude and the distribution of the net benefit. Specifically when P_x is above domestic clearing price (as in Figure 2), the net benefit will be larger, ceteris paribus, the lower the export price. For as P_x falls, the altitude of the two net benefit triangles, and hence the net benefit itself, is proportionately increased. The magnitude of the efficiency gain also increases if the supply or demand elasticities are greater. Higher elasticities mean the two curves are flatter, and since the two ex ante supply and demand points (B and D) are fixed, the flatter curves imply longer bases for the two triangles. On the other hand if either elasticity is zero, the corresponding triangle disappears, and the net benefit is reduced.

¹Part of the efficiency gain stems from the quota on subsidy eligibility. If this quota is removed, subsidy payments will distort marginal supply incentives, and the net benefit is reduced to triangle BHI.

The distribution of gains and losses is also affected by these two factors. A lower export price increases the consumer gain and the producer loss. The impact upon taxpayers is ambiguous in sign, but the absolute value of the taxpayer change always rises-- i.e., if taxpayers gain (lose) with a high export price, they will gain (lose) even more with a lower price. The effect of higher demand and supply elasticities is somewhat more complex. A higher demand elasticity means that the consumer surplus change is greater in absolute value (the base of trapezoid ABHJ is longer), while a greater supply elasticity means the absolute value of the producer impact is smaller (the base of trapezoid CDFG is shorter). Since the sign of the consumer effect is always positive and the sign of the producer effect is negative, both producers and consumers gain if elasticities increase. Budgetary costs, however, are unaffected by elasticity changes.

The magnitude and distributional effects are somewhat different when export price is below the domestic clearing price, P_d . This situation is illustrated in Figure 3. Since P_x is less than P_d , under a direct-subsidy scheme all production is consumed domestically ($Q_d^2 = Q_s^2$). The price-support system, however, must still dispose of surplus production through dumping on the international market. Since these dumping costs are much higher (both absolutely and relatively) when P_x is less than P_d , the net benefit has an added component not found in the previous cases--namely the rectangle EIKL. Under these circumstances the export price, as well as the demand and supply

FIGURE 3



elasticities, still affect the magnitude of the net benefit, but in a slightly different way. As export price falls, the cost of price supports rises without any offsetting losses under a direct subsidy system, so the net benefit increases rapidly. Higher demand and supply elasticities also increase the net benefit. The flatter curves raise the equilibrium price and shrink the "empty" triangle BDF. The

distributional effects are also somewhat changed. Lower export prices lead to greater taxpayer gains, but have no effect upon consumers and producers. Taxpayers also benefit from higher supply and demand elasticities, while the impact upon consumers and producers is ambiguous.

The key conclusions of the analysis to this point can be summarized as follows:

- (1) Switching from a price-support to a direct-subsidy system will always yield a positive economic benefit. The magnitude of this efficiency gain is greater,
 - (a) when the elasticities of supply and/or demand are larger, or
 - (b) when the export price is lower.
- (2) Consumers always gain from a change to a direct subsidy system. If $P_x > P_d$, this gain is greater,
 - (a) when the elasticity of demand is larger, or
 - (b) when export price is lower.
- (3) Producers always lose from the switch to direct subsidies. If $P_x > P_d$, their loss is minimized,
 - (a) when the elasticity of supply is larger, or
 - (b) when export price is higher.
- (4) The effect upon taxpayers is indeterminate--they may either benefit or lose from the change to direct subsidies. If $P_x < P_d$, the taxpayers gain is greater (or their loss smaller),

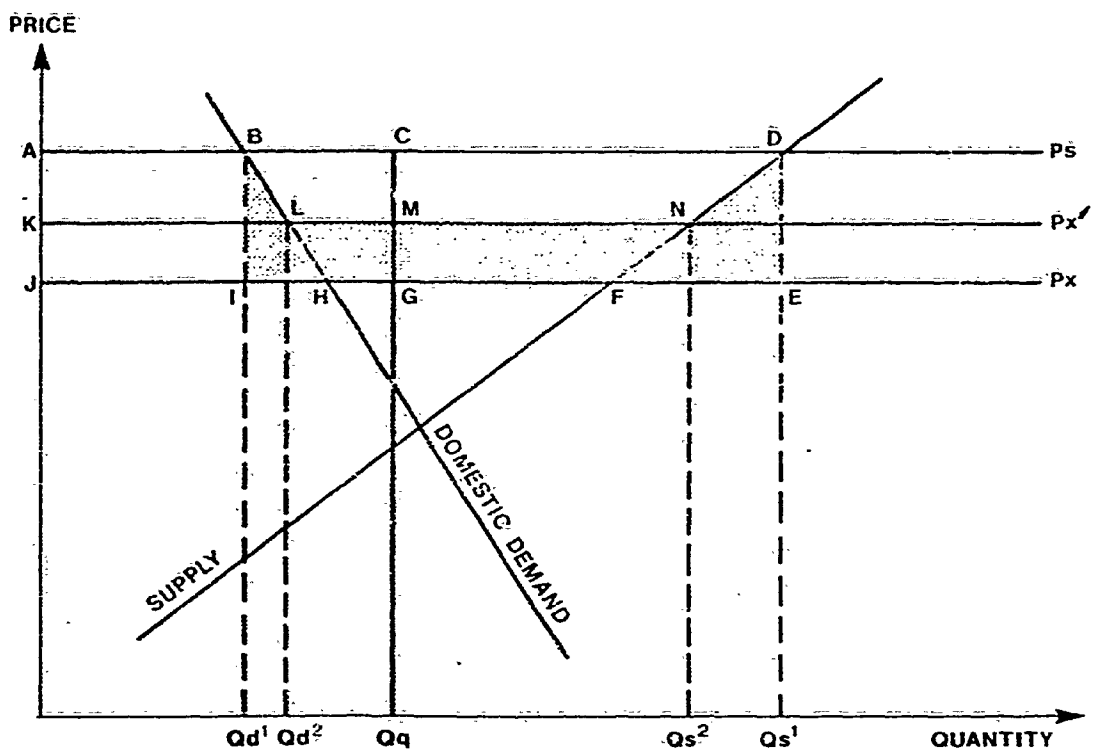
- (a) when the elasticities of supply and/or demand are larger, or
- (b) when export price is lower.

Two additional conclusions can be added to this list:

(5) Any mixed support system (such as that operated by the CDC) will register an efficiency gain over a pure-price support scheme, but will be less efficient than a system using only direct subsidies. The truth of this statement is easy to see, for under a mixed support system, the market intervention is literally a combination of the two separate policies. A portion of the effective support comes through high-efficiency direct subsidies and the remainder through inefficient price supports--the total system is intermediate in efficiency.

(6) Relaxing the small country assumption merely increases the margin of advantage of direct subsidies over price supports. If Canadian exports do depress international prices, this feedback effect will tend to minimize the potential gains from trade. Furthermore, since the (dumped) exports under a price-support system are always greater than the (autonomous) direct-subsidy exports, the feedback will be greatest under the former scheme. These conclusions can be illustrated with the aid of Figure 4. Under a price-support system, export price is P_x (as in Figure 2). With the introduction of direct subsidies, Canadian exports fall and the international price is raised to P_x' . The budgetary costs of price supports are unchanged and equal rectangle BDEI. Under a direct-subsidy system these costs become

FIGURE 4



rectangle ACMK. The consumer gain is trapezoid ABLK, and the producer loss is trapezoid CDN M. Therefore,

$$\begin{aligned}
 \text{Net Benefit} &= \text{Budgetary cost of price supports} \\
 &\quad - \text{Budgetary cost of the direct subsidies} \\
 &\quad + \text{Gain in consumer surplus} \\
 &\quad - \text{Loss in producer surplus}
 \end{aligned}$$

or $\text{Net Benefit} = \text{rec. BDEI} - \text{rec. ACMK} + \text{trap. ABLK} - \text{trap. CDMN}$
hence $\text{Net Benefit} = \text{triangle BHI} + \text{triangle DEF} + \text{trap. LNEH}$
 $= \text{shaded area in Figure 4.}$

The net benefit, therefore, is greater with an endogenous export price by an amount equal to trapezoid LNEH.

5. AN ECONOMETRIC MODEL OF THE DAIRY INDUSTRY

The analysis of the previous chapter provides tentative conclusions about the relative efficacy of price supports and direct subsidies within the context of idealized conceptualizations of both the dairy industry and the federal intervention programs. The actual validity of these conclusions cannot be ascertained by the derivation of a more sophisticated theoretical apparatus, but can only be judged empirically. The present chapter presents a detailed econometric model of the Canadian dairy industry capable of making such empirical simulations.

5.1 Basic Design of the Model

In designing the structure for the econometric model, the basic goal is to model the market as it actually existed during the period of estimation (including the inherent institutional constraints such as the price-support scheme). The model is then modified in Chapter 6 to depict the market as it would have existed under alternative dairy support systems.

It should be emphasized at the outset that the model described below is limited in scope, for only the industrial-milk sector is considered. Because of the institutional constraints described in Chapter 2, the fluid-milk market during the period of estimation was virtually a separate entity from its industrial counterpart and hence

has been ignored.¹

The primary product, industrial milk, can be used for a variety of different purposes. However, the two chief uses, butter and cheese processing, together account for between 85 and 90 percent of all (industrial) milk shipments during the estimation period. Since the remaining uses (ice cream, casein, evaporated milk, yogurt, cottage cheese, condensed milk, etc.) are both small and heterogeneous, it was decided that they could be ignored in the building of the model. The milk for cheese processing is shipped as whole milk and processed into cheese (chiefly cheddar) and its by-product, whey. Although whey is bought and sold as a commercial product, its value is small and hence it too was ignored in the model-building.

The milk-for-butter market is more complex. In addition to cream (which is converted to butter), the whole milk yields a valuable by-product, skim milk. Some producers separate their milk on the farm and ship only cream, retaining the skim milk to use as feed. All other producers ship whole milk which is separated by the processor into cream for butter and skim milk for skim milk powder. Because of high capital costs, separating equipment is as a rule used by producers who can only ship cream (i.e., those far away from whole milk

¹This clear-cut separation has been somewhat obscured in recent years by policy changes such as the evolution of the market share quota system discussed in Chapter 2 and by the increased flow of fluid cream (the residual from partially skimmed fluid milk) into the industrial market.

processing facilities). However, a certain amount of substitution between whole milk and cream shipments is possible--particularly if the relative prices of skim milk and feed change substantially.

The model itself consists of three sectors: production, processing, and consumption. The production sector includes the basic behavioural relationships affecting farmers' decisions about (1) the amount of milk to produce, (2) the distribution between whole milk and cream shipments, and (3) the (processing) market to which these shipments are made. The processing sector includes demand equations for each of the three "intermediate" products (milk-for-cheese, butterfat, and skim milk), and supply equations translating each of these intermediate products into their corresponding end products (cheese, butter, and skim milk powder). Finally the consumption sector consists of the three final demand equations.

5.2 Estimating Technique and Data

Before describing each equation of the econometric model in detail, a few preliminary statements about the data and choice of the estimating technique should be made:

(1) Each stochastic equation of this simultaneous system was estimated by ordinary least squares. Equations which exhibited significant residual autocorrelation¹ were re-estimated using the Hildreth-Lu procedure.

¹Significant autocorrelations were tested at the 1% level by using the Henshaw test on the Durbin-Watson statistic.

(2) Most equations were estimated with annual data over the time period 1958 through 1971, although in some cases a shorter estimation period was used. 1958 was chosen as the initial date for the analysis since before this time there was no effective price support system for dairy products. To estimate equations over a period in which such a major institutional change occurred would have been difficult, if not impossible.

(3) All price and value data were calculated in deflated terms (1961 base year) to abstract from any nominal price effects.

(4) The definitions of all variables are given in Table 2.¹

TABLE 2

VARIABLE DEFINITIONS

Input Quantities:

- (1) Q_m = Quantity of milk and cream produced for butter, skim milk powder and cheese processing.
Units: millions of pounds of milk equivalents.
- (2) Q_c = Quantity of cream produced for butter processing.
Units: millions of pounds of milk equivalents.
- (3) Q_{mb} = Total quantity of whole milk shipped for butter-skim milk powder processing.
Units: millions of pounds of milk.
- (4) Q_{mch} = Quantity of milk shipped for cheese processing.
Units: millions of pounds of milk.

¹ Sources for the data used are described in Appendix III.

- (5) Qbf = Quantity of total butterfat (i.e., the butterfat in both cream and whole milk) shipped to butter processors.
Units: millions of pounds of the milk equivalent of total butterfat shipments.
- (6) Qmlk = Total quantity of whole milk shipment to butter/skim-milk-powder and cheese processors.
Units: millions of pounds of milk.
- (7) Qsm = Total quantity of skim milk component of whole milk supplied to butter/skim-milk-powder processors.
Units: millions of pounds of milk equivalent.

Output Quantities:

- (8) Sb = Supply of creamery butter marketed.
Units: millions of pounds of butter.
- (9) Db = Demand for creamery butter by Canadian consumers.
Units: millions of pounds of butter.
- (10) Ssmp = Supply of skim milk powder marketed.
Units: millions of pounds of skim milk powder.
- (11) Dsmp = Demand for skim milk powder by Canadian consumers.
Units: millions of pounds of skim milk powder.
- (12) Sch = Supply of cheese marketed.
Units: millions of pounds of cheddar and processed cheese.

- (13) D_{ch} = Demand for cheese by Canadian consumers.
Units: millions of pounds of cheddar and processed cheese.

Input Prices:

- (14) P_{mch} = Price for milk paid by cheese processors.
Units: \$ per hundredweight of milk.
- (15) P_{mb} = Price for milk paid by butter/skim-milk-powder processors.
- (16) P_m = Price of milk.
Units: \$ per hundredweight of milk.
- (17) P_{bf} = Price for butterfat (cream) paid by butter processors.
Units: cents per pound of butterfat.
- (18) P_{sm} = Implicit price for skim milk paid by butter and skim-milk-powder processors.
Units: cents per hundredweight of milk equivalent.

Output Prices:

- (19) P_b = Price of butter paid by wholesalers.
Units: cents per pound of butter.
- (20) P_{smp} = Price of skim milk powder paid by wholesalers.
Units: cents per pound of SMP.
- (21) P_{ch} = Price of cheddar cheese paid by wholesalers.
Units: cents per pound of cheddar cheese.

Other Variables :

- (22) Y = Net national income.
 (23) T = Time trend (1958 = 1).
 (24) Pmrg = Price of margarine paid by wholesalers.
 Units: cents per pound of margarine.
 (25) Pfd = Index of the price of feed.

5.3 Production Sector

The production sector consists of five equations: an overall milk-equivalent supply equation, a skimming decision equation, and two arbitrage conditions. Each equation describes a separate, although interrelated step in the farmer's optimizing decision. The supply equation gives the initial "scale of plant" decision which, with a year lag, determines the overall milk-equivalent supply. The skimming equation captures the separation choice--whether a farmer ships this production as whole milk or as cream. The arbitrage conditions are derived from the assumption that no significant differences could exist among the prices paid for milk for the various processing functions without arbitrage forcing this differential toward zero.

5.3.1 Milk-Equivalent Supply Function

From a statistical viewpoint this equation is the least tractable of the entire model. Numerous specification attempts were made using various types of simple cobweb and distributed lag models. Yet it was never possible to obtain a statistically satisfying equation for the 1958-71 time period.

There are probably two causes of this difficulty. First, there is a serious point-cluster problem caused by the stagnation of milk-equivalent production during the estimation period. Both (real) market price and quantity variations are quite small, and what "endogenous" variations do occur can easily be swamped by "disturbance" factors such as variations in weather conditions.

Second, the one consistent result of all these attempts is that contemporaneous price is totally unrelated to production. This statistical finding conforms to the accepted industry view that any substantive production change can only be made by changing the milking herd size--and this takes time. A farmer, therefore, must make his supply decision on the basis of expected rather than actual price. Normally this would not be too important, as the use of distributed lag models has been quite successful in many similar situations. However, this procedure is almost certainly doomed to failure in the present case because of the amazingly complex and ever-changing structure of prices applicable to different kinds of production. During the estimation period the per unit returns a farmer received varied not only with market prices, but also with many other factors such as whether or not the production was covered by the subsidy quota, the current level of the gross subsidy, the size of penalties, levies, etc. Table 3 portrays the major complexities existing during the three relevant fiscal years. Both milk and cream production are subdivided into three categories: production covered by the Subsidy Eligibility Quota (SEQ), production in excess of SEQ, and production by farmers

TABLE 3

Price Structure in the Industrial Milk Market
(P is the nominal market price in \$/cwt for milk and ¢/lb.
butterfat for cream)

PRODUCER GROUP	FISCAL YEAR		
	1969-70	1970-71	1971-72
<u>MILK</u>			
SEQ PRODUCTION	P + \$.99 ¹	P + \$.99 ¹	P + \$1.15 ¹
EXCESS PRODUCTION BY SEQ HOLDERS	P - \$.52	P - \$1.25	{ P - \$1.25 (Apr-May) P - \$1.05 (Jun-Mar)
PRODUCTION BY THOSE WITHOUT AN SEQ	P	P	P
PRODUCTION IN EXCESS OF MSQ	N.A. ³	N.A. ³	P - \$2.40
<u>CREAM</u>			
SEQ PRODUCTION	P + 35¢ ²	P + 35¢ ²	P + 35¢ ²
EXCESS PRODUCTION BY SEQ HOLDERS	P - 1¢	P - 8¢	{ P - 8¢ (Apr-May) P - 5¢ (Jun-Mar)
PRODUCTION BY THOSE WITHOUT AN SEQ	P	P	P
PRODUCTION IN EXCESS OF MSQ	N.A. ³	N.A. ³	P - 50¢

¹The net subsidy consists of a gross subsidy of \$1.25 and a holdback (to cover export costs) of \$.26 in the 1969-70, and 1970-71. In 1971-72 the holdback was reduced to \$.10.

²The net subsidy in each year consists of a gross subsidy of 35.71¢ and a holdback of 1.00¢.

³The Market Share Quota system did not exist prior to 1971-72.

without SEQ. In addition for the year 1971-72, producers were subject to the Market Share Quota System (MSQ), which created a fourth category of production. Considering this kaleidoscope of prices and returns (often varying widely from one year to the next), it does not seem surprising that neither the econometrician nor the farmer is able to find an appropriate proxy for expected price.

In the face of these problems, an alternative procedure for estimating a milk supply function was adopted: the period of estimation was changed to 1928-1962. By truncating the most recent (and most interference-ridden) years and by extending the time series, it was possible to minimize both the point cluster problem and the price distortion effects.

A distributed-lag model of the type used by Nerlove¹ was postulated. By hypothesizing that desired production is dependent on expected price, and that expected price is a decaying exponential function of past observed prices, it is possible to derive an equation for supply in terms of lagged price and lagged quantity. With the addition of the lagged exogenous variable, Pfd, this procedure yielded the following statistically significant equation (figures in parentheses are t-statistics):²

¹Nerlove, M., "Estimates of the Elasticities of Supply of Selected Agricultural Commodities," Journal of Farm Economics, May, 1956.

²It should be noted that use of the Koyck transformation to obtain the specification form of equation (1) results in a violation of the assumptions of the general linear model. In particular, the disturbance term of the transformed equation is correlated with Q_{m-1} . The

Equation (1)

$$Q_m = 1627 + .906 Q_{m-1} + 103 P_{m-1} - 10.6 P_{fd-1}$$

(2.37) (15.2) (1.87) (-.276)

$$r^2 = .923$$

Even this equation, however, leaves something to be desired. The coefficient on the price variable, while of the proper sign, is only significant at the 10% level. Furthermore, the estimated supply elasticities seem rather low--at the sample means the impact elasticity is only .030 while the equilibrium elasticity is .319.¹ Nevertheless the equation should suffice as a fairly accurate guide to the supply decision.

5.3.2 Skimming Decision Equation

The farmer's decision whether to ship his milk production as whole milk or cream is probably dependent upon two factors. The economic influence is the opportunity cost of the skim milk--namely its alternative use as feed. It can therefore be expected that the proportion of milk/cream shipments is inversely proportional to the feed/skim milk price ratio. The institutional factor is the availability of whole-milk processing facilities. Because of the high

ordinary least squares estimates of the structural coefficients are, therefore, inconsistent. See, for example, the discussion in J. Kmenta, Elements of Econometrics (Macmillan Co., 1971), p. 479.

¹On the other hand the estimated elasticities may be low because the actual elasticities are low--certainly the production series for milk is remarkably stagnant even over a twenty-year time period covering an economic depression and a World War.

perishability and steep transportation costs of milk, markets tend to be regionalized and in many areas of the country producers can only ship to creameries. In recent years this institutional problem has gradually lessened as multi-product processors have expanded their number of plants. Therefore, the ratio of milk to cream shipments should be positively correlated with a time trend variable.

Ideally the skimming equation should account for both factors. Therefore the initial, estimated equation was as follows (again the numbers in parentheses are t-statistics):¹

$$Q_{mlk} = -12066 + 1.71 Q_m = 27.3(P_{fd} - P_{sm}) + 136.3 T$$

$$(-2.79) \quad (3.35) \quad (-.974) \quad (.268)$$

$$r^2 = .873 \quad dw = 1.90$$

The "fit" of this equation is quite respectable, and the price and time trend coefficients are of the proper sign--but both t-statistics are miserable. The explanation for this problem is the high multicollinearity ($r = -.957$) between P_{fd} and T . Because of this high degree of collinearity it was necessary to settle for only one of these explanatory variables. The price variable was chosen because of its (relatively) high t-statistic. The resulting equation is:

¹It should be noted that the influence of relative price has been expressed in difference, rather than ratio form. This linearization was necessary to conform to the structure of the remaining equations. Solving the final equation system would otherwise be an almost impossible job.

Equation (2)

$$Q_{mlk} = -1202 + .86 Q_m - 42.7(P_{fd} - P_{sm})$$

$$\begin{matrix} (-3.05) & (4.68) & (-6.66) \end{matrix}$$

$$\bar{r}^2 = .894 \quad dw = 2.53$$

In all respects equation (2) is a more satisfying equation: the statistic on price is vastly improved, the coefficient on Q_m is much more satisfactory, and the adjusted r^2 is even slightly higher.

5.3.3 Arbitrage Conditions

These equations represent one of the crucial behavioural assumptions of the entire model--namely, that the price of milk will be the same regardless of processing use.¹ Specifically,

$$\text{Equation (3)} \quad P_m = P_{mb}$$

$$\text{Equation (4)} \quad P_{mb} = P_{mch}$$

The arbitrage conditions can be arrived at by assuming that farmers always ship to the highest-paying market. However, even this postulate is not really necessary. Since milk for cheese and milk for butter are indistinguishable from one another, with no inherent or acquired product differentiation, arbitrage should assure that the two prices are identical. This identity would not hold if institutional factors or differential transportation costs served to separate the

¹This premise can no longer be considered completely valid because of provincial regulatory intervention. For example, under the Ontario Milk Marketing Board's (OMMB) Classified Pricing System, the prices (to processors) of industrial milk differ depending on the end use. Specifically, the price of milk for butter/powder is kept systematically (though marginally) lower than the price of milk for other industrial uses. Because the OMMB is essentially the sole supplier of milk in the province, it can enforce this differential price structure.

two markets. However, over the estimation period neither of these effects was present to any significant degree, and time-series data on the two prices follow virtually identical patterns.

It is not possible to statistically test the first equation since P_m is not a published series. However, there are separate observations on P_{mb} and P_{mch} , allowing the following equation to be estimated. (In this one case the parenthetical figures are standard errors):

$$P_{mb} = .571 + .795 P_{mch}$$

$$(1.29) \quad (.157)$$

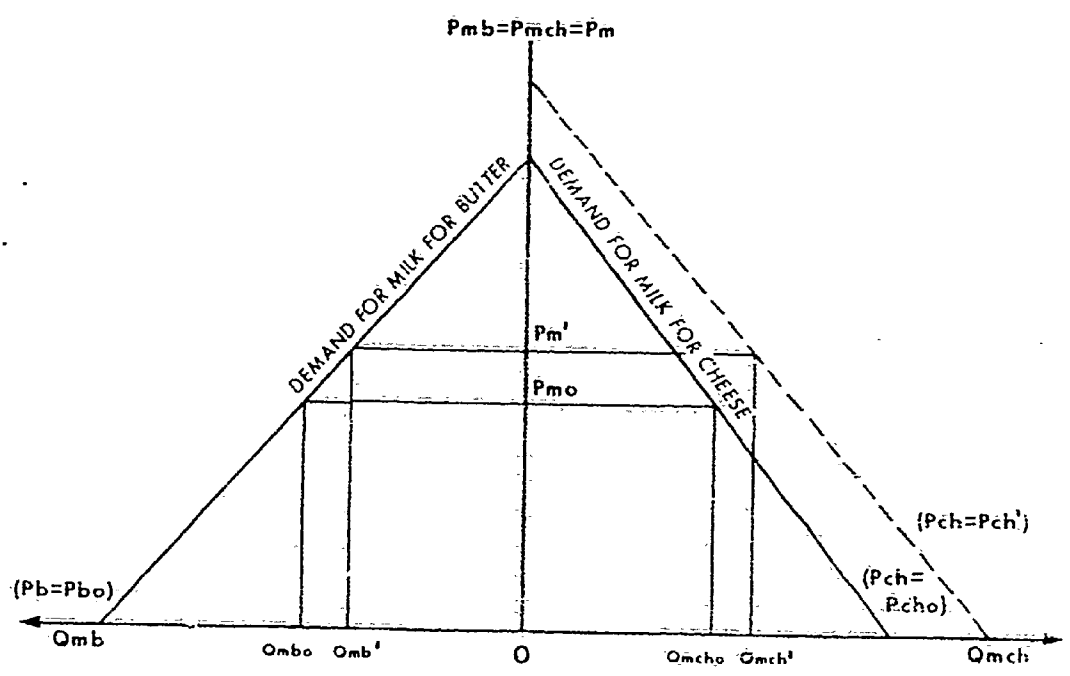
$$r^2 = .804 \quad dw = 2.08$$

At the 5% level the intercept is not significantly different from zero and the regression coefficient is not significantly different from one. This test tends to validate equation (4).

The implications of the arbitrage conditions can be illustrated with the aid of Figure 5. For ease of explanation, assume that the quantity of cream shipped is fixed, as is the total quantity of milk. Under the present price-support system the prices of the final products, butter and cheese, are determined exogenously so that the demand curves (illustrated in Figure 5) are uniquely determined. The shared vertical price axis is the geometric analogue of the perfect arbitrage condition. Under these circumstances the portion of total milk shipments going to butter processors is Q_{mb_0} and that going to cheese processors is Q_{mch_0} . Both markets are then in equilibrium since supply is equal to demand in both cases, and since $P_{mb} = P_{mch}$. Now

suppose that the government raises the support price for cheese to P_{ch}' without changing the butter price. This action shifts the demand curve for cheese milk (to the dashed curve in Figure 5) and causes an instantaneous rise in P_{mch} , both absolutely and in relation to P_{mb} .

FIGURE 5



However, this differential increase cannot be maintained as at least some farmers react by shipping more and more of their milk to the cheese market until P_{mb} and P_{mch} are again equal. Alternatively, at least some cheese processors bid for milk being shipped to the butter market--again with the effect of equalizing P_{mb} and P_{mch} . In the new equilibrium both milk prices have risen by the same amount (to $P_{m'}$),

but cheese milk shipments have increased to Q_{mch} while milk for butter shipments have fallen to Q_{mb} . Thus the shift in demand is translated into a reallocation of milk between the two markets. This arbitrage process is a powerful and key element of the econometric model.

5.3.4 Definitional Identities

The following definitional identities must be added to the production sector:

$$\text{Equation (5)} \quad P_{mb} \equiv .035 P_{bf} + .01 P_{sm}$$

$$\text{Equation (6)} \quad Q_m \equiv Q_c + Q_{mlk}$$

$$\text{Equation (7)} \quad Q_{mlk} \equiv Q_{mch} + Q_{mb}$$

$$\text{Equation (8)} \quad Q_{bf} \equiv Q_c + Q_{mb}$$

The first of these equations defines (implicitly) the price of skim milk as the difference between the price of milk for butter and the price of butterfat. The non-unitary coefficients are the result of differences in the units used to measure each variable. Equation (6) states that the total milk-equivalent production will be shipped as either whole milk or cream. Equation (7) breaks down milk shipments into their two processing components. Finally, equation (8) states that total butterfat shipments (in milk-equivalent units) are the sum of cream shipments and milk for butter shipments.

5.4 Processing Sector

The processing sector consists of three demand and three supply equations. The demand equations are derived demand relationships. From the processor's view, the basic classification of dairy inputs is

not milk and cream, but the trichotomy--skim milk, butterfat, and milk for cheese. Furthermore, the demand for each of these products is related not only to its own price, but also to the price of its corresponding output product.

The specification of the supply functions is quite unusual and requires some explanation. The production process for cheese, butter, and skim milk powder is one of almost perfectly fixed coefficients. Given amounts of skim milk (or cream) will always produce the same quantity of skim milk powder (or butter). The processing of cheese allows slightly more latitude because of its numerous varieties. But even in this case the assumption of fixed coefficients is quite accurate since cheddar accounts for such a large fraction of total cheese production. The technological fact of fixed coefficients, together with the inherent perishability of milk and cream, greatly simplify the specification, for the supply of each final product can be estimated as a simple linear function of the amount of milk-input processed.

5.4.1 Demand for Skim Milk Equation

The demand for skim milk is a function of three variables: price of skim milk, price of skim milk powder and time trend. Time trend was included to capture the effects of institutional changes occurring during the sampling period. The steady increase of the number of firms which can process whole milk (and therefore manufacture skim milk powder) contributed to a secular growth in the demand

for skim milk.¹

Equation (9)

$$Q_{sm} = - 41425 + 4905 P_{simp} + 2082 T - 632.9 P_{sm}$$

(-9.34) (5.7) (9.27) (-3.95)

$$r^2 = .874 \quad dw = 3.10$$

where

Equation (10)²

$$Q_{sm} \equiv Q_{mb}$$

The estimated equation is quite satisfactory. All coefficients are of the anticipated sign and are statistically significant.

5.4.2 Demand for Butterfat Equation

The estimated demand function is:

Equation (11)

$$Q_{bf} = - 6955 + 1700 P_b - 1475 P_{bf}$$

(-1.75) (4.97) (-5.81)

$$r^2 = .759 \quad dw = 2.69$$

Again the statistical fit is reasonably good and the price coefficients have significantly "proper" values. It should be noted that the institutional change mentioned in the previous section does not affect this equation, since butterfat can be processed from either whole milk or cream.

¹Cf. the discussion on the skimming decision in Section 2.2.

² Q_{sm} is given in milk equivalent units. It is therefore identical to the quantity of milk for butter.

5.4.3 Demand for Milk for Cheese Equation

Demand for cheese milk is given by:

Equation (12)

$$Q_{mch} = 3230 + 391.6 P_{ch} - 5587 P_{mch}$$

$$\begin{matrix} (5.46) & (3.30) & (-2.84) \end{matrix}$$

$$r^2 = .711 \quad dw = 1.68$$

This equation is somewhat less satisfactory than the previous two as both the overall statistical fit and the individual t-statistics are worse. Nevertheless the equation is well-behaved and should provide a reasonable indicator of cheese milk demand.

5.4.4 Processor Supply Equations

As noted above, the supply equations for skim milk powder and for butter are definitional identities based upon the fixed-coefficient production process. They are given by:

Equation (13) $S_{smp} \equiv .078 Q_{sm}$

Equation (14) $S_b \equiv .0427 Q_{bf}$

The cheese supply function is not an exact identity because of the heterogeneous variety of cheeses. Nevertheless, the predominance of cheddar cheese suggests the specification of the same functional form. Accordingly, the following equation was estimated:

Equation (15)

$$S_{ch} = .0901 Q_{mch}$$

$$(11.0)$$

$$r^2 = .903 \quad dw = 1.73$$

The explanatory power of equation (13) appears to be sufficient to confirm the use of this structural form.

5.5 Consumption Sector

Under current CDC policies the prices of the three final products--butter, cheese, and skim milk powder--are all artificially supported by the government. Over the period of estimation these support policies were effective in that the quantity supplied almost always exceeded the quantity demanded, with the surplus purchased by the CDC and dumped on the foreign market. The estimation of the final demand curves for these commodities is therefore greatly simplified since the identification problem is entirely eliminated. The demand equations are all relatively straightforward. In each case demand is estimated as a function of the product price, (real) personal income, the price of a substitute product (if one exists), and in one case an exogenous time trend.

5.5.1 Demand Equation for Butter

The demand for butter is a function of four variables:

Equation (16)

$$D_b = 464 - 6.46 P_b + 5.26 P_{mrg} + .404 Y - 11.3 T$$

$$(13.5) \quad (-9.77) \quad (5.36) \quad (2.77) \quad (-3.1)$$

$$r^2 = .938 \quad dw = 2.09$$

The first three regression coefficients all have the expected signs, i.e., the price elasticity is negative, the income elasticity is positive, and the cross-price elasticity of the substitute, margarine, is positive. Time trend has been included as a proxy for consumers'

awareness of progressive improvements in the quality of margarine. This variable also has the appropriate sign and is important. If it is dropped, its effect is captured by the highly correlated income variable to such an extent that the estimate of the income elasticity becomes negative--a most implausible result.¹

The statistical tests are quite satisfactory: the overall fit is very good, and the coefficients are all significant at the 5% level.

5.5.2 Demand Equation for Skim Milk Powder

Equation (17)

$$D_{smp} = 88.5 - 2.77 P_{smp} + .265 Y$$

(4.11) (-1.87) (3.34)

$$r^2 = .729 \quad dw = 2.98$$

Although the price and income coefficients do conform to prior expectations, the statistical tests produce less conclusive results than those performed on the demand for butter equation. The value of the r^2 is lower and the coefficient on price is significant only at the 10% level. It should be noted that the data used for this equation are less reliable. Consumption of both butter and skim milk powder is determined as a residual between production and exports. The skim milk

¹ Failure to note this fact led to severe difficulties in J. L. Pando's "Trend Patterns of Butter Consumption in Canada," Canadian Farm Economics, Dec. 1970, pp. 28-37. Despite the title, Pando did not include a time trend in his estimated equation and went through heroic contortions to explain an income elasticity of -.68.

powder market was in severe glut during much of the estimation period while butter exports have been nominal. Inaccuracies in recording the quantities of exports therefore seriously affect the reliability of the consumption of skim milk powder series, but have little impact on the butter consumption series.

Attempts to find an important substitute for skim milk powder were not successful. The demand for skim milk powder was regressed on the price of fluid milk in addition to the variables listed in the final form but this new variable was not statistically significant.

5.5.3 Demand Equation for Cheese

The estimated equation for cheese demand was initially,

$$Dch = 67.2 - 1.93 Pch + .315 Y$$

$$(2.52) \quad (-2.02) \quad (10.8)$$

$$\bar{r}^2 = .943 \quad dw = .800$$

Because of the high residual autocorrelation this equation was rejected. The equation was re-estimated using the Hildreth-Lu procedure.

The resulting modified equation is:

Equation (18)

$$Dch = 67.2 - 1.99 Pch + .322 Y$$

$$(2.38) \quad (-2.13) \quad (10.1)$$

$$\bar{r}^2 = .864 \quad dw = 1.22 \quad (\rho = .522)$$

5.6 Final-Demand Income and Price Elasticities

The price and income elasticities of demand for butter, skim milk powder and cheese were calculated from the estimates of the regression coefficients, and are given in Table 4. The relative structure of these elasticities generally conforms to initial expectations.

For example, the demand for butter, which is the only product that has a well-defined substitute, has the highest price elasticity and cheese, which is something of a "luxury" food, has the highest income elasticity. The income elasticity of demand for butter does seem rather low but otherwise there are no surprises.

TABLE 4

	Price Elasticity	Income Elasticity
Demand for butter	-1.1	0.44
Demand for cheese	-0.62	1.03
Demand for skim milk powder	-0.26	0.62

N.B.: Price and income elasticities are taken at the respective sample means.

5.7 Full Equation Set

The final equation system, derived in the previous sections, is summarized below (predetermined variables are starred; endogenous, unstarred):

$$\text{Equation (1)} \quad Q_m = 1627 + .906Q_{m-1}^* + 103P_{m-1}^* - 10.6P_{fd-1}^*$$

$$\text{Equation (2)} \quad Q_{mlk} = -1202 + .86Q_m - 42.7(P_{fd}^* - P_{sm})$$

$$\text{Equation (3)} \quad P_m = P_{mb}$$

$$\text{Equation (4)} \quad P_{mb} = P_{mch}$$

$$\text{Equation (5)} \quad P_{mb} = .035P_{bf} + .01P_{sm}$$

$$\text{Equation (6)} \quad Q_m = Q_c + Q_{mlk}$$

$$\text{Equation (7)} \quad Q_{mlk} = Q_{mch} + Q_{mb}$$

$$\begin{aligned} \text{Equation (8)} \quad Q_{bf} &= Q_c + Q_{mb} \\ \text{Equation (9)} \quad Q_{sm} &= -41425 + 4905P_{smp}^* + 2082T^* - 632.9P_{sm} \\ \text{Equation (10)} \quad Q_{sm} &= Q_{mb} \\ \text{Equation (11)} \quad Q_{bf} &= -6955 + 1770P_b^* - 1475P_{bf} \\ \text{Equation (12)} \quad Q_{mch} &= 3230 + 391.6P_{ch}^* - 5587P_{mch} \\ \text{Equation (13)} \quad S_{smp} &= .078Q_{sm} \\ \text{Equation (14)} \quad S_b &= .0427Q_{bf} \\ \text{Equation (15)} \quad S_{ch} &= .0901Q_{mch} \\ \text{Equation (16)} \quad D_b &= 464 - 6.46P_b^* + 5.26P_{mrg}^* + .404Y^* - 11.3T^* \\ \text{Equation (17)} \quad D_{smp} &= 88.5 - 2.77P_{smp}^* + .322Y^* \\ \text{Equation (18)} \quad D_{ch} &= 67.2 - 1.99P_{ch}^* + .322Y^* \end{aligned}$$

5.8 Future Work on the Model

There are numerous possibilities for improving the model as it now stands. The most important modifications are given below.

(1) The Export Market: As the model now stands, all export prices are exogenous to the Canadian dairy market. Since Canadian exports presently represent a relatively small fraction of the total international market, this assumption is probably not too far-fetched. Nevertheless, accuracy would be improved by incorporating explicit price-determining equations for exports. This addition probably represents a difficult, although not impossible task.

(2) Other Industrial Milk Sectors: As a longer-term project it should be possible to extend the model to include the remaining 13 percent of industrial milk production. Chiefly this would involve

the inclusion of the ice cream and evaporated milk sectors. Data on these sectors are more limited so modelling may be more difficult. However, there do not appear to be any insurmountable difficulties to such an extension.

(3) The Fluid Milk Sector: Given the increasing interactions between the fluid and industrial sectors, if the model is to be used to evaluate the most recent dairy support policies, it is almost certainly necessary to extend the model to cover the fluid milk sector. This would be a relatively major task, because of the importance and heterogeneity of provincial programs affecting fluid production, processing, and distribution.

6. RELATIVE ECONOMIC EFFICIENCY: AN EMPIRICAL ANALYSIS

The econometric model derived in the previous chapter is designed to replicate the actual mixed support system used by the CDC during the period of estimation. To estimate and compare the empirical effects of a pure price-support or a pure direct-subsidy scheme (paralleling the theoretical analysis of Chapter 4), it is necessary to modify the equation system to conform to the new "rules of the game". The basic approach in these simulations is identical to that of Chapter 4: in each instance the returns on the quota production of milk and cream are kept constant while gains and losses to all other affected groups are summed to obtain the net benefit.

The empirical analysis, however, does face some complications which did not affect the theoretical inquiries. First, from the econometric model it is clear that processors, in addition to producers, consumers, and taxpayers would be directly affected by changes in the dairy support system. Accordingly all the net benefit calculations of this chapter include changes in processor surplus.

A second and more difficult complication is that the theory of Chapter 4 is comparative static while the econometric model, and the dairy market itself, are dynamic. There are two methods of meeting this problem (there are of course no true solutions). One is to compute equilibrium gains or losses; the other is to simulate the first year impact solution. Although both approaches have their limitations, the impact method was chosen as presenting a clearer picture of the actual market situation. The model itself is essentially short run in nature, and while a fairly accurate instrument for this purpose, its ability to predict movements over an extended period is severely limited. Furthermore, one of the chief characteristics of the industrial dairy market is its susceptibility to rather violent exogenous shocks, such as rapid changes in international prices for dairy products. To speak of simulated changes in equilibrium values under these circumstances appears to be about as speculative as a wild-catter's oil claim. Finally even the theoretical basis for computing equilibrium effects appears to be quite tenuous, as several of the exogenous variables (such as net national income) have implicit or explicit time-dependent components.

A final complication arises from the multiple-market nature of the dairy industry as depicted in the econometric model of the previous chapter. Multiple markets, by themselves, would present no

difficulties if each market equilibrium was independently determined. Unfortunately, although the demand curves of the econometric model are indeed independent, the supply functions are not. Changes in the support structure for say skim milk powder will in general affect the supply of butter (and for that matter the supply of cheese). The critical question is whether consumer surplus analysis is robust enough to remain valid in the "extended partial equilibrium" case of shifting supply curves.

In order to adequately answer this concern it is useful to first note that the procedure used in Chapter 4 for calculating net benefits is somewhat different from that used in classical consumer surplus theory. The usual approach is to sum the difference between marginal social benefit and marginal social cost over the induced change in quantity supplied. This procedure leads to the usual welfare cost triangles resulting from taxes, subsidies, and other market distortions. The geometric derivations of Chapter 4, although in the end leading to the same result, concentrate on the gains and losses accruing to the affected interest groups (consumers, taxpayers, and producers). This procedure has been adopted for three main reasons:

- (1) More information is obtained. Policy-makers (and hopefully policy analysts) are interested not only in the direction and magnitude of efficiency changes, but also in the intermediate information of the distribution of benefits (and costs) to different groups. At the very least this permits some crude idea of the income distributional effects of the proposed policy change. (For example, if the product

affected is a low-income-elasticity food commodity, consumer and taxpayer benefits may not be weighted equally.)

(2) Approaching a policy maker with a measurement (no matter how accurately obtained) of some hypothetical measure called an efficiency gain is not always a rewarding activity. The policy maker very rightly would like to know something about where this welfare benefit appears--or in other words, who specifically gains from this increased efficiency.

(3) On the more prosaic level, the indirect method of computing welfare changes can be accomplished through very simple arithmetic algorithms. Even in the multi-market case (as given by the econometric model of the previous chapter), gains and losses can be calculated in a straightforward manner with no more information than the initial and simulated vectors of commodity prices and quantities. This point is discussed more fully later.

The issue of the robustness of consumer surplus analysis in the multi-market case now separates into two separate questions. First, does the concept itself remain theoretically valid? And second, does the procedure for calculating the gains and losses for individual groups yield theoretically correct results? The first question was specifically addressed by Harberger in his discussion of the general equilibrium extension of consumer surplus.¹ Assuming the analyst is

¹Harberger, op. cit., pp. 789-91.

willing to accept the three welfare postulates cited in Chapter 4, Harberger demonstrates that consumer surplus analysis can indeed be used to calculate the change in welfare. Specifically, for linear supply and demand curves, the change in welfare (ΔW) induced by a new distortion (D_j^*) in market j can be given by:

$$\Delta W = \frac{1}{2} D_j^* \Delta X_j + \sum_{i \neq j} D_i \Delta X_i$$

where D_i represents the distortion (the excess of marginal social benefit over marginal social cost) in market i

and ΔX_i and ΔX_j represent the induced change in commodities i and j , respectively.

The first expression in the above equation is the usual welfare change in the primary market (and must be negative). The second expression represents the "spillover" effects in other markets. Some of these effects may make positive contributions to welfare, and indeed their aggregate influence may outweigh the partial equilibrium welfare loss. Harberger makes one other important point. The only secondary markets which need be considered in estimating the aggregate welfare change are those in which there are both significant quantity changes and significant (ex ante) distortions.

Now to the second major question--does the procedure of estimating component gains and losses yield the same estimate of welfare change? Intuitively it would seem clear that it should--efficiency gains must after all accrue to someone. Furthermore, the calculation of benefits and costs to the various groups is in essence a specific

application of the Harberger welfare postulates. Nevertheless, it is useful to illustrate the congruence between the two approaches with a couple of specific examples.

Assume there are two interrelated markets--whose demand curves are independent, but whose supply curves are jointly determined. Initially there exists a distortion in market A in the form of a price-support system (maintained by an offer-to-purchase, import controls, and subsidized exports). If this support system is dropped, it is clear that the direct welfare effect in market A is precisely that calculated in Chapter 4--and corresponds to the first term of the Harberger welfare equation.

In market B, the removal of price supports is assumed to shift the supply curve outward. The impact of this shift on total welfare depends on the existence and nature of any distortions in market B. Two specific possibilities will be examined. First, assume that market B is free of taxes, subsidies, price supports and other distortions. This situation is portrayed in Figure 6. The initial supply/demand equilibrium is at point B. When the price support in market A is dropped, the supply curve in B shifts to the right and the new equilibrium is established at point D. Computation of the change in consumer welfare is straightforward,

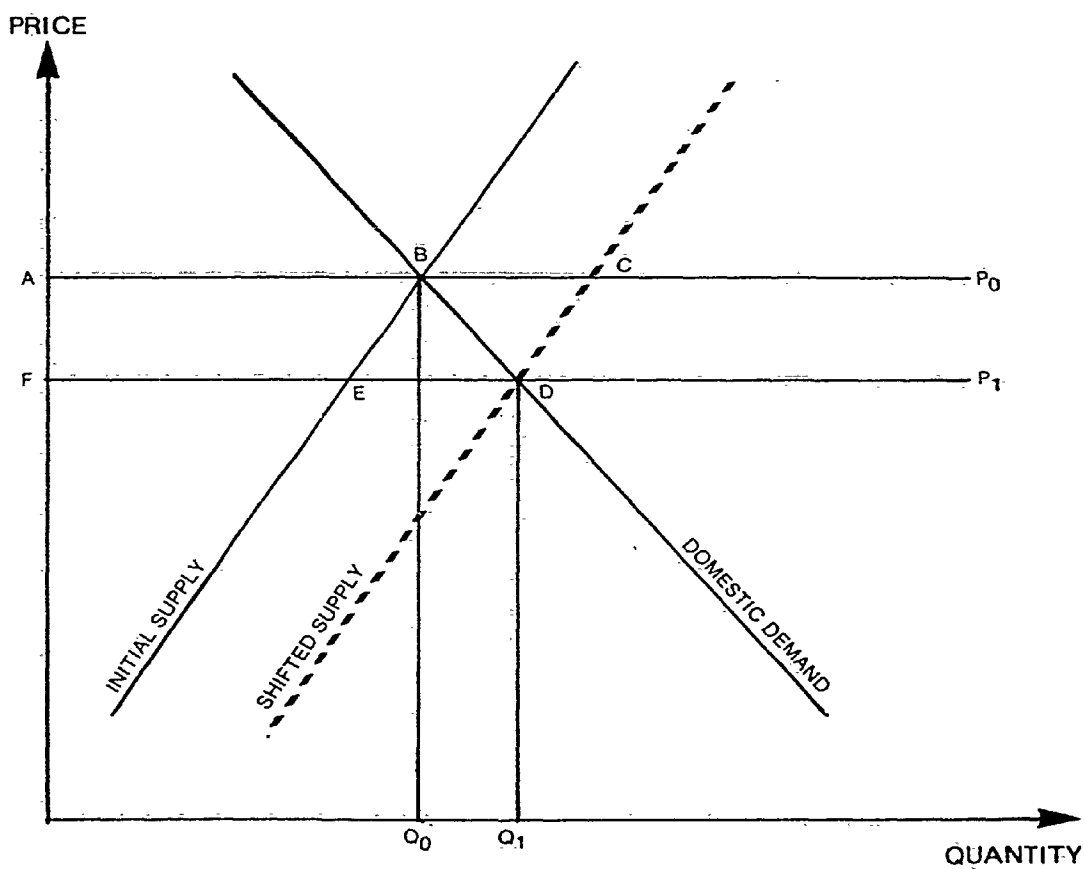
$$\Delta \text{ Consumer surplus} = \text{trapezoid ABDF} = (P_0 - P_1)(Q_0 + Q_1)/2$$

Computing the effect on producers, however, is more difficult. It is clear that producer welfare declines, since the supply price falls, but calculation of the exact magnitude is complicated by the

shifting supply curves. The quandary can be resolved by returning to the welfare postulate that the value of a marginal unit of production to the producer is equal to the competitive supply price. As the supply curve shifts from its initial to its final position, it is clear that the locus of "interim" competitive supply points is precisely the segment BD of the demand curve. In other words the fall in producer welfare is precisely,

$$\Delta \text{ Producer surplus} = (P_1 - P_0)(Q_0 - Q_1)/2$$

FIGURE 6



The change in total welfare--the net benefit--is simply the sum of the producer and consumer effects (since by assumption there is no impact on taxpayers):

$$\begin{aligned}\Delta \text{ Welfare} &\equiv \Delta \text{ Consumer Surplus} + \Delta \text{ Producer Surplus} \\ &\equiv (P_0 - P_1)\Delta Q + (P_1 - P_0)\Delta Q \\ &= 0\end{aligned}$$

In other words, the technique reproduces the classical result that induced supply/demand effects have no welfare impact in a market without distortions.

In passing it is interesting to note the relationship between the change in producer surplus computed above and the effect on producers that would have occurred with fixed supply curves. If there is an induced drop in price from P_0 to P_1 and the supply curve remains in its original position, the corresponding loss is equal to trapezoid ABEF in Figure 6. If the supply curve is fixed in its final position, the cost to producers is equal to trapezoid ACDF. By simple plain geometry it is clear that the actual loss in producer welfare is simply the arithmetic average of these lower and upper bounds--a result which is both intuitively and aesthetically satisfying.¹

As a second illustration, assume that a distortion also exists in market B. Specifically--to parallel Harberger's own example--

¹It should be noted, however, that such a result only holds when both supply and demand curves are linear. For curvi-linear relationships, the change in surplus will still lie between the two bounds but not at the midpoint.

assume the distortion consists of a fixed per unit subsidy on B. This situation is portrayed in Figure 7. Initially price to suppliers is P_1 , while the consumer price is P_2 . The taxpayer cost is the amount of the subsidy, s ($= P_1 - P_2$), times the quantity produced, Q_0 . When the price support in market A is dropped, the supply curve for B shifts to the right. Consumer price drops from P_2 to P_4 , while price to producers falls by the same amount to P_3 . At the same time production increases from Q_0 to Q_1 . The increase in consumer surplus is,

$$\Delta \text{ Consumer surplus} = (P_2 - P_4)(Q_0 + Q_1)/2$$

The effect on producers is obtained in the same way as the previous example. Namely,

$$\Delta \text{ Producer surplus} = (P_3 - P_1)(Q_0 + Q_1)/2$$

Finally the effect on taxpayers is given by

$$\Delta \text{ Taxpayer cost} = s(Q_1 - Q_0)$$

The change in total welfare, therefore, is

$$\Delta \text{ Welfare} = (P_2 - P_4)(Q_0 + Q_1)/2 + (P_3 - P_1)(Q_0 + Q_1)/2 - s(Q_1 - Q_0)$$

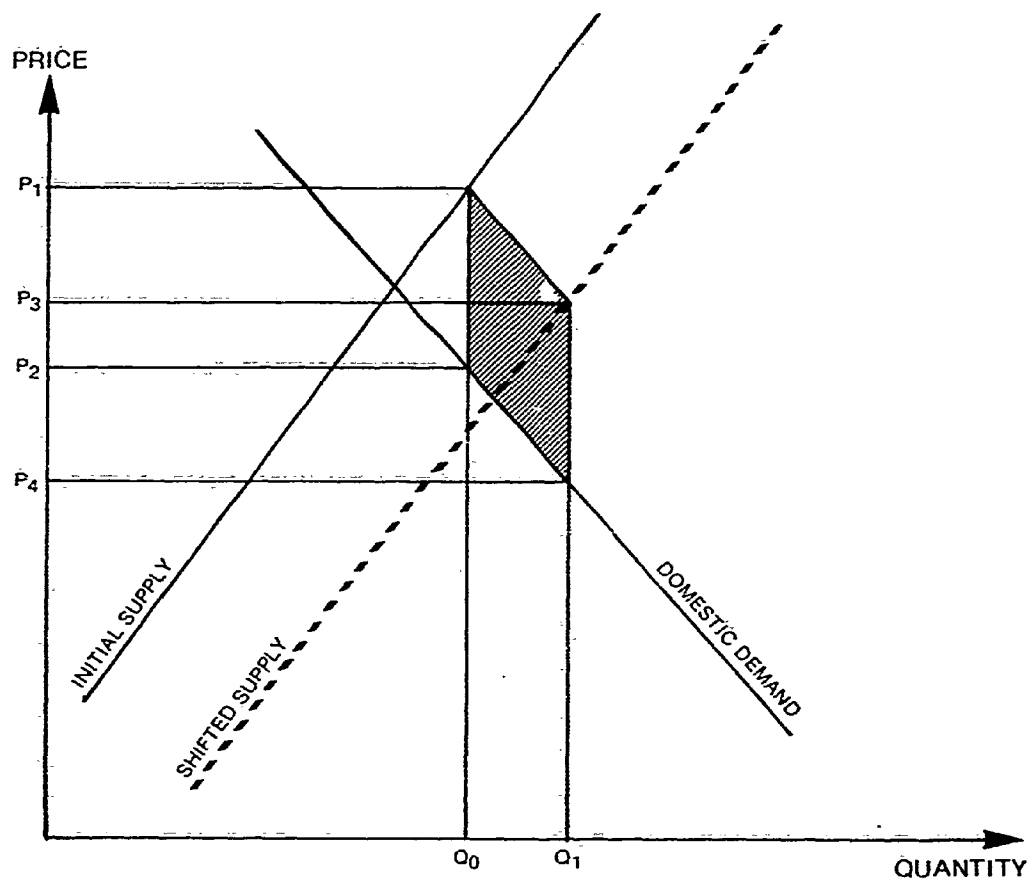
And since $(P_2 - P_4) = - (P_3 - P_1)$,

$$\Delta \text{ Welfare} = - s(Q_1 - Q_0)$$

Welfare falls by an amount equal to the level of the subsidy times the change in the quantity supplied which is precisely the Harberger result.

The net benefit procedure, therefore, does generalize to the multi-market case, yielding an accurate measure of welfare gain or loss, even with shifting supply curves.

FIGURE 7



The procedure for calculating the effects of price support and direct subsidy systems, therefore, consists of two general parts. First, the "rules of the game" are altered in such a way that the econometric model of Chapter 5 can simulate the price/quantity vector that would have occurred under each of these two polar schemes. The general procedures used to effect these simulations are discussed in Sections 6.1 and 6.2. Second, given the initial and simulated data on prices and quantities for the entire vector of dairy commodities, the effects on each interest group are calculated by using the net benefit

procedure outlined above. Specifically, the impacts on producers and consumers are given by,

$$\Delta \text{ Consumer Surplus} = \sum_i (P_{0i} - P_{1i}) (Q_{0i} + Q_{1i}) / 2$$

$$\Delta \text{ Producer Surplus} = \sum_j (P_{1j} - P_{0j}) (Q_{0j} + Q_{1j}) / 2$$

where (P_0, Q_0) and (P_1, Q_1) represent the initial and final price/quantity vectors respectively

and i is summed over all consumer commodities

while j is summed over all producer commodities .

The change in processor surplus is calculated in an analogous way to the producer surplus procedures. However, instead of the change in price, the change in processor value-added is used. Finally, the change in taxpayer welfare is simply given by the net budgetary saving. And of course, the total welfare change or net benefit is simply the arithmetic sum of the four component gains and losses.

The entire simulation procedure is described in detail in Appendix I.

The effects of both price support and direct subsidy systems are simulated for each of the last three fiscal years of the estimation period: 1969-70, 1970-71, and 1971-72. The use of fiscal year, rather than calendar year, simulations conforms to CDC budgetary practices, but necessitates some manipulation of the data base. In most cases, fiscal-year values are approximated by simply interpolating the appropriate calendar year figures. In some instances monthly or quarterly data series, or use of other information, permit more exact

estimates.

6.1 Simulating the Pure Direct Subsidy System

The basic rationale of the direct subsidy system is that final product prices would be permitted to reach their "free-market"¹ level while support for quota production is maintained through increased subsidies--the entire structure of levies, penalties, price supports, etc. would be abandoned. To simulate this system, therefore, it is necessary to alter the econometric model so that P_b , P_{ch} , and P_{smp} are endogenous, rather than exogenous, variables. Normally this would be done by adding the equilibrium conditions,

$$(i) \quad D_b = S_b$$

$$(ii) \quad D_{ch} = S_{ch}$$

$$(iii) \quad D_{smp} = S_{smp}$$

In the present case, however, it is possible for the domestic clearing price for one or more of the products to be below the world export price. In this case the product price is no longer endogenous to the system, but instead assumes the (exogenous) international value. The excess of domestic supply over domestic demand then represents freely-marketed exports. To equilibrium conditions (i)-(iii), therefore, it is necessary to add the following constraints:

$$(iv) \quad P_b^d \geq P_b^x$$

$$(v) \quad P_{ch}^d \geq P_{ch}^x$$

$$(vi) \quad P_{smp}^d \geq P_{smp}^x$$

¹"Free-market" is in quotes because import controls are maintained--see, however, Section 6.6.

where superscript d denotes the prevailing domestic price and superscript x , export price.

One further alteration of the model is necessary to make the model suitable for simulation purposes. The equation system provides estimates of the total quantities of milk and cream produced, but provides no clue to how much of this supply comes from quota production, non-quota production, and over-quota production. Since the (*ex ante*) effective rates of return on these three classes of production are quite different, any simulated change in the price of milk or the price of cream will affect each class differently--the sum of these effects is "known" but the component breakdown is not. Therefore, to accurately calculate the change in producer surplus, it is necessary to disaggregate the skimming equation. Ideally this should be done by estimating three distinct skimming equations. Unfortunately separate production data are available for an insufficient number of years to permit such statistical estimation.

The alternative adopted here is to derive disaggregated parametric equations from the overall skimming equation. Specifically, the derivation used the following procedure. First, quota production should be unaffected by the introduction of a direct subsidy system, since by definition the effective rates of return for quota milk and cream will be kept constant. Hence, it is only necessary to derive equations for non-quota and over-quota production. Second, it is assumed that the response functions of all classes of production are

"similar"--namely that the price and quantity elasticities in the skimming equation are identical. From this assumption the derivation of coefficients for price and quantity is quite simple. Finally the intercept can be computed as a residual, by standardizing the parametric equation for the mean values of all variables. By using this procedure, the following relationships were obtained:

$$Q_{mlk,i} \quad \text{unchanged}$$

$$Q_{mlk,2} = - 112.4 + .86Q_{m,2} - 3.09(P_{fd} - P_{sm})$$

$$Q_{mlk,3} = - 1113 + .86Q_{m,3} - 6.98(P_{fd} - P_{sm})$$

where,

- (a) subscripts 1, 2, and 3 denote quota, over-quota, and non-quota production respectively, and

$$(b) \sum_{i=1}^3 Q_{mlk,i} = Q_{mlk}$$

$$(c) \sum_{i=1}^3 Q_{m,i} = Q_m$$

6.2 Simulating The Pure Price-Support System

Because of the multi-product nature of the dairy industry, the price support system is not as unambiguously defined as the direct subsidy system. Obviously all aid is to come via price supports, but the question is what combination of price supports? There are two constraints on the support structure (the market prices of milk and cream must be equal to the ex ante quota returns on these inputs), but there are three policy instruments (P_b , P_{ch} , and P_{smp}). For any desired milk and cream prices, there exist an infinite number of

support-price combinations which will yield these input prices. A number of approaches could be used to meet this problem. Perhaps the most elegant would be to treat the support-price decision as an optimization problem. The econometric model and the desired milk and cream prices form the constraints, the three output prices the variables, and the net benefit calculus the objective function. Despite the appeal of such a procedure, it is unlikely that its sophistication would result in any greater understanding of the actual decision-making process. The approach actually used is far more arbitrary but also much simpler. For each price-support simulation the support level for cheese is fixed by raising its value in rough proportion to the desired increase in the price of milk for cheese. This eliminates the extra degree of freedom in the equation system so that the butter and skim milk powder support prices become part of the system's solution set.

A further definitional problem arises with respect to the various levies and penalties included under the present support system. Again the decision made about these policy instruments is quite arbitrary. All charges against quota production are set to zero so that per unit returns are identically equal to market price. Penalties against over-quota production are maintained at the ex ante levels.

Finally, the parametric skimming equations, described in the previous section, are also necessary to the price-support simulations. They are therefore included in the equation system without change.

6.3 Simulation Results: 1969-70

The basic simulation results for fiscal year 1969-70 are presented in Table 5.

In general, the figures conform to a priori expectations: prices are generally lower under the direct subsidy system than under the actual support scheme, while the price-support values are almost uniformly higher.¹ Some of the particular numbers, however, are quite interesting, and in several cases, rather unexpected.

A major characteristic of the direct-subsidy results is that the equilibrium value for both the price of cheese and the price of skim-milk powder is equal to the international (export) level rather than the domestic clearing value. In both instances these simulated prices are substantially less than the observed ex ante figures. The

¹It should be noted that the vector of simulated prices and quantities given in Table 5 represent point estimates of the values that would have prevailed if the respective support systems had been in effect during the fiscal year 1969-70. There is, of course, a region of uncertainty around these point estimates. Precise estimation of this uncertainty is difficult since, for many of the variables, statistical inferences about forecast error are complicated by the simultaneous nature of the equation system. However, it is likely that a 95% confidence interval for at least some of the variables would be moderately wide. To give some idea of the order of magnitude of the statistical uncertainty, the 95% confidence interval was calculated for D_{ch} and D_{smp} under the price support system. (In these particular instances no simultaneous equation problems exist since the simulated P_{ch} and P_{smp} are exogenously, policy-determined). The resulting intervals were 100.4 to 144.8 for D_{ch} (compared to a point estimate of 122.6), and 146.8 to 224.6 for D_{smp} (compared to a point estimate of 185.7).

Similar comments apply to the simulation results for 1970-71 and 1971-72 given in Tables 7 and 9.

skim-milk powder market, in particular, collapses almost completely: the price of skim-milk powder drops from almost 16 cents per pound to less than 5 cents, and the skim-milk input plummets from nearly 90 cents a hundredweight to just over 6 cents.

The butter and cream market, on the other hand, represents something of an anomaly. Both input and output prices are marginally higher than their ex ante analogues--despite the fact that the butter market was in excess supply at the (lower) support level!

The answer to this paradox lies in the interdependent nature of the overall dairy market. Skim milk powder and butter are joint milk products produced in fixed proportion to one another. Under the actual support structure, the product with far and away the greatest surplus supply was skim milk powder (over 200 million pounds excess, while both cheese and butter had a surplus of less than 20 million pounds).

These facts lead to the following interpretation of the butter-price anomaly. When the support prices are abandoned, the bottom drops out of the skim milk powder market forcing processors to adjust to the new situation in two ways. First they decrease the price of skim milk which results in some marginal adjustment by farmers from whole milk to cream shipments.¹ Second, processors

¹This shift would be more substantial except that, for the 80% of production covered by quota, the effective prices to farmers does not change--since lower market prices are offset by higher subsidies.

TABLE 5

1969-70 Simulation Results¹

	<u>Observed Values Under Actual Mixed Support System</u>	<u>Simulated Values Under Direct Subsidy System</u>	<u>Simulated Values Under Price Support System</u>
<u>Input Prices</u>			
Pm	2.70	1.90	3.48
Pc	51.53	52.40	78.95
Psm	89.55	6.34	71.68
<u>Butter Market</u>			
Pb	51.37	52.46	74.15
Db	323.90	320.6	176.8
Sb	340.0	320.6	334.4
<u>Cheese Market</u>			
Pch	36.54	26.28 ²	48.00
Dch	145.4	160.3	122.6
Sch	158.3	190.6	167.3
<u>Skim Milk Powder Market</u>			
Psm _p	15.81	4.84 ²	13.44
Dsm _p	179.1	217.3	185.7
Ssm _p	406.5	317.1	383.2

¹ All figures are in the units given in Table 2; prices are in deflated 1961 dollars or cents.

² Prices determined by the international market.

tend to shift their milk processing to cheese/whey and away from butter/skim-milk-powder. The net result of this second adjustment is that the supply of butter, as well as skim milk powder, is decreased. This supply shift, in turn, causes both butter and cream prices to rise.

The results of the pure price-support simulation are much more straightforward. Perhaps the outstanding feature is the tremendous glut on the butter market; under the actual support structure the butter surplus was 16 million tons, under a pure price-support scheme the excess would be almost ten times as large.

Given the two solution sets, the calculation of the resulting gains and losses to each of the four affected interest groups is quite straightforward. These calculations are summarized in Table 6.

The theoretical analysis of Chapter 4 concluded that a direct subsidy would be more efficient than a price support system, while any combination scheme would be intermediate in efficiency. This hypothesis is consistent with the results in Table 6. Adoption of a pure direct subsidy system would have resulted in a net-benefit gain of almost 11 million dollars, but complete dependency on price supports would have meant a net loss of 54 million dollars. The total efficiency difference between the two "unadulterated" systems is therefore 65 million dollars--a rather impressive amount considering that the aggregate market value of the three dairy products in 1969-70 was less than 300 million dollars. Finally, it should be noted that the relative magnitude of the two net benefit figures indicates that the actual

TABLE 6

1969-70 Net Benefit Calculations
(in millions of Constant, 1961 dollars)

Change in:		Gains and Losses Under a Pure Direct Subsidy System	Gains and Losses Under a Pure Price Support System
Consumer Surplus	=	+ 36.95	- 68.07
Taxpayer Saving	=	- 16.18	- 9.93
Processor Saving	=	- 1.68	- 0.33
Producer Surplus	=	- 8.25	- 24.14
Net Benefit		+ 10.84	- 54.19

system was far closer to the direct subsidy ideal than to the price support alternative.

In general then the 1969-70 net benefit calculations support the previous theoretical analysis. The direct subsidy scheme is more efficient than either the price support system or the actual mixed support approach. Furthermore, as hypothesized, consumers are the largest (and indeed the only) beneficiaries of this increased efficiency. Finally the magnitude of the net benefit gains is very significant, particularly between the two polar support systems.

6.4 Simulation Results: 1970-71

The 1970-71 simulation results are summarized in Table 7. In general the figures are similar to the 1969-70 values: both input and output prices are generally lower under the direct subsidy system and higher under a pure support scheme than the actual observed values.

TABLE 7
1970-71 Simulation Results¹

	Observed Values Under Actual Mixed Support System	Simulated Values Under Direct Subsidy System	Simulated Values Under Price Support System
<u>Input Prices</u>			
Pm	2.73	2.40	3.49
Pc	50.64	59.13	77.26
Psm	95.35	33.55	78.59
<u>Butter Market</u>			
Pb	50.07	56.59	72.38
Db	324.0	282.4	180.4
Sb	324.1	282.4	333.4
<u>Cheese Market</u>			
Pch	38.71	36.59 ²	49.00
Dch	156.9	161.2	136.5
Sch	171.8	240.5	156.6
<u>Skim Milk Powder Market</u>			
PsmP	16.01	7.71 ²	13.85
DsmP	151.0	174.0	157.0
SsmP	377.4	252.9	380.0

¹All figures are in the units given in Table 2; prices are in deflated, 1961 dollars or cents.

²Prices determined by the international market.

There are, however, several significant differences. In 1969-70 international dairy prices were depressed below their historical averages; by the following year these prices had risen back to, or even slightly above, their trend values. The impact of this rejuvenated export market can be seen in the results of the direct subsidy simulation. Neither the cheese nor the skim milk powder price falls as appreciably as in the previous year. Furthermore, the rise in the butter and cream prices, which was marginal in 1969-70, is quite large in 1970-71. One result of these differences is that simulated input prices are significantly higher in 1970-71 than they were in 1969-70. A second result--the effect upon consumers--is discussed below in the analysis of the net benefit figures. The net benefit calculations themselves are listed in Table 8.

These figures again support the hypothesis that direct subsidies are more efficient than either pure price supports or the actual mixed-support scheme. The magnitude of the efficiency gains is somewhat less than in 1969-70--indeed the advantage of direct subsidies over the actual system is cut in half. Yet this fact, too, is consistent with the theoretical conclusion that the size of the net benefit, ceteris paribus, should be inversely related to the export price level.

The startling result of Table 8 is that consumers would actually lose from the adoption of a direct subsidy system. This loss is in total contradiction to both intuition and the previously developed theory. Under the actual support structure, the butter market was in

TABLE 8

1970-71 Net Benefit Calculations
(in millions of constant 1961 dollars)

Changes in:		Gains and Losses Under a Pure Direct Subsidy System	Gains and Losses Under a Pure Price Support System
Consumer Surplus	=	- 3.12	- 68.05
Taxpayer Saving	=	+ 2.73	- 6.36
Processor Surplus	=	+ 2.64	+ 0.81
Producer Surplus	=	+ 3.13	+ 26.54
Net Benefit		+ 5.38	- 47.06

almost exact equilibrium while an excess supply existed in both the cheese and skim milk powder markets. It seems almost inconceivable that abandoning these price supports could result in a consumer loss. Yet this is just what happens: the price of butter rises and more than offsets consumer gains on the other two products.

The explanation for such a truly startling result lies not in some perverse consumer behaviour, but in the complexities and interconnections of the different product markets. The first link in the chain is the joint product nature of skim milk powder and butter which, as discussed in Section 6.3, causes the butter price to rise. The consumer is compensated for this increment to butter price by the resulting increase in the supply of cheese. "Normally" these gains on cheese (in combination with lower skim milk powder prices) would outweigh the butter losses. But in the present instance the export

price of cheese is very close to the ex ante support price (37 cents per pound versus 39 cents). The consumer benefits from the shift in cheese supply are therefore quite limited, as most of this increased supply is just exported. Hence the effects of the butter market dominate, and the consumer does indeed lose.

6.5 Simulation Results: 1971-72

Export price rises were substantial in 1970-71; in 1971-72 they were even larger. The cheese export price, in fact, rose through the CDC floor level, making price support operations unnecessary. At the same time bad weather conditions reduced the milk and cream shipments to processors. Because of this supply shift, butter production decreased, creating an excess demand at the support price level. The CDC imported millions of pounds of U.S. butter to prevent the price from rising above this value.¹ Only the skim milk powder market continued to have an excess supply--but even this was considerably reduced from previous years.

The impact of these exogenous changes can be seen in the simulation results summarized in Table 9. Both input and output prices are uniformly the highest of any of the three years. Furthermore, the

¹The CDC action appears contradictory to the usual image of the CDC as a protector of producer interests. However, it is consistent with the CDC's aversion to volatile prices. The import intervention was also financially remunerative--yielding a profit of several million dollars.

TABLE 9
1971-72 Simulation Results¹

	Observed Values Under Actual Mixed Support System	Simulated Values Under Direct Support System	Simulated Values Under Price Support System
<u>Input Prices</u>			
Pm	3.02	2.87	3.78
Pc	51.31	58.79	77.57
Psm	122.54	80.74	106.51
<u>Butter Market</u>			
Pb	50.10	55.85	71.94
Db	323.5	286.3	182.4
Sb	296.0	259.0 ²	292.5
<u>Cheese Market</u>			
Pch	42.95 ³	42.95 ³	54.00
Dch	146.5	146.5	124.5
Sch	190.7	251.2	196.4
<u>Skim Milk Powder Market</u>			
PsmP	19.21	13.58 ³	17.11
DsmP	190.4	206.0	196.2
SsmP	333.2	235.9	314.3

¹All figures are in the units given in Table 2; prices are in deflated, 1961 dollars or cents.

²To insure comparability with the actual support system, butter was also "imported" under the direct subsidy system. If this correction is not made, the efficiency gain resulting from import controls would distort the net benefit comparison of the two support schemes.

³Prices determined by the international market.

direct subsidy figures are not tremendously different from the actual observed prices and quantities. The cheese price and quantity demanded, in fact, are identical under the two systems--reflecting the exogenous influence of the export market. Under these conditions, the expectation is that efficiency differences among the three systems would be at a minimum, and this view is supported by the net benefit calculations of Table 10.

The direct subsidy system is still the most efficient, but its advantage over the actual support system is only marginal. The pure price support scheme remains firmly in last place, although the usual large consumer loss is partially offset by significant taxpayer and producer gains. The narrowing of the efficiency gaps, as noted in the previous section, is a logical outgrowth of the extremely high export prices. The mechanisms for this net-benefit convergence are quite diverse. For the direct subsidy system the chief cause is the doubling of consumer losses. This adverse effect, in turn, is caused by the intensification of supply diversion to cheese processing. Since the cheese price is already at its export level, this increased supply goes entirely for export. The improved performance of the pure price support system, on the other hand, is almost entirely due to the fact that the \$6 million taxpayer loss of 1970-71 is turned into an \$11 million gain--the high export prices significantly lower surplus-disposal costs.

TABLE 10

1971-72 Net Benefit Calculations
(in millions of constant 1961 dollars)

Change in:		Gains and Losses Under a Pure Direct Subsidy System	Gains and Losses Under a Pure Price Support System
Consumer Surplus	=	- 6.32	- 66.15
Taxpayer Saving	=	+ 1.74	+ 10.90
Processor Surplus	=	+ 3.13	+ 1.10
Producer Surplus	=	+ 3.17	+ 22.85
Net Benefit		+ 1.67	- 31.30

6.6 The Question of Import Controls

The analysis of the dairy support system has concentrated so far on only two of the three main policy instruments employed by the CDC. The relative efficiency of price supports and direct subsidies has been considered in some detail, but the efficiency impact of import controls was ignored. Naturally, it is impossible to run a price support system (or any mixed scheme involving effective price supports) without some form of stringent controls.¹ However, it is perfectly feasible to channel support through direct subsidies and omit import

¹The alternative is to impose domestic production controls, as well as price controls. The supply management aspect of the current dairy support program bears a strong resemblance to such an approach. This issue is discussed briefly in Appendix II.

quotas or even tariffs entirely. Furthermore, the econometric model of Chapter 5 can be used to simulate the resulting impact on the dairy markets.

Despite these facts a direct subsidy system without import controls was not given major consideration as a third alternative support scheme. This decision was made for two main reasons. First, the abandonment of such extensive import restrictions would almost certainly lead to much more severe structural and institutional changes than either of the other alternatives. It may be possible to discern the basic shape of some of these changes, but it would be extremely difficult to predict the magnitude of all the important effects. Certainly, the econometric model is incapable of estimating such structural discontinuities. Second, the model has limitations even within its own, strictly empirical, realm. The magnitude of relative price changes and the resulting reallocation of resources is likely to be significantly greater than in any previous simulation. Although the model is probably quite accurate for a reasonably large set of price/quantity vectors, the flexibility of the model could well be strained past its reliable limit.

Because of these two limitations, it would be unwise to attach the same significance to a set of free-trade simulations as to the direct subsidy and price support results given previously. Nevertheless it is probably useful to have some rough idea of the impact of import controls. Accordingly, a free-trade system was simulated for one year. 1970-71 was chosen as being most nearly representative of a "normal" year for international dairy prices. The small-country

assumption was retained for lack of any reasonable alternative.

The results of this simulation run are summarized in Table 11. The most striking feature of the "free-trade" figures is the tremendous processing specialization and product reallocation. Skim milk powder production disappears completely as domestic demand is met entirely through imports. Furthermore, butter production is limited to butter processed from cream shipments (which have no alternative processing use)--the remaining demand is again filled through imports. On the other hand, cheese production skyrockets--it is more than double the direct subsidy result and almost three times the observed value. In fact the entire milk supply is devoted to cheese processing--with the result that over 300 million pounds of cheese are exported.

Another feature of the free trade results is quite important. Although the price of milk is considerably reduced, the cheese price is down only marginally from its observed value and is identical to the direct subsidy figure. The margin on cheese processing, therefore, is considerably increased. This fact is reflected in the net benefit calculations of Table 12 (for comparison purposes the direct subsidy gains and losses are also included).

TABLE 11

Simulation of Free-Trade Support System (1970-71)¹

	<u>Observed Values Under Actual Mixed Support System</u>	<u>Simulated Values Under Direct Subsidy System</u>	<u>Simulated Values Under "Free Trade" System²</u>
<u>Input Price</u>			
Pm	2.73	2.40	1.78
Pc	50.64	59.13	40.05
Psm	95.35	33.55	37.52
<u>Butter Market</u>			
Pb	50.07	56.59	38.71
Db	324.0	282.4	397.9
Sb	324.1	282.4	132.5
<u>Cheese Market</u>			
Pch	38.71	36.59	36.59
Dch	156.9	161.2	161.2
Sch	171.8	240.5	485.2
<u>Skim Milk Powder Market</u>			
PsmP	16.01	7.71	7.71
DsmP	151.0	174.0	174.0
SsmP	377.4	252.9	0

¹All figures are in the units given in Table 2; prices are deflated, 1961 dollars or cents.

²The direct subsidy system without import controls.

TABLE 12

Net Benefit Calculations for Free Trade
Support System (1970-71)
(in millions of constant 1961 dollars)

Change in:		Gains and Losses Under Direct Subsidy System	Gains and Losses Under Free-Trade System
Consumer Surplus	=	- 3.12	+ 60.82
Taxpayer Saving	=	+ 2.73	- 44.66
Processor Surplus	=	+ 2.64	+ 23.03
Producer Surplus	=	+ 3.13	- 18.96
Net Benefit		+ 5.38	+ 20.23

Most of the results given in Table 12 are not surprising.

Abandoning import controls does indeed result in an efficiency gain--a net benefit of \$20 million over the actual support system, and \$15 million over the direct subsidy scheme. Furthermore the large taxpayer and producer losses, as well as the even greater consumer gain, all conform to a priori expectations. The one startling result is the substantial gain registered by processors--despite the discontinuation of skim milk powder production, and the cutback in butter production. The explanation for the processor gains lies in the cheese market. The tremendously increased cheese margin, discussed previously, coupled with the large volume of cheese exports, places processors in a far better situation than under any other support system.

7. CONCLUSIONS

If aid is given to industrial milk farmers, a support scheme using direct subsidies is economically more efficient than either a pure price support system or the present combined support approach.

For the three representative fiscal years the estimated efficiency advantage of a direct subsidy is given in Table 13.

TABLE 13

	Economic Efficiency Margin of Direct Subsidy System ¹	
	Vs. Price Support System (in millions of constant 1961 dollars)	Vs. Actual CDC Support System
1969-70	65.03	10.84
1970-71	52.44	5.38
1971-72	32.97	1.67

¹The present structure of import controls on dairy products is maintained under all three systems.

These figures indicate that the superiority of direct subsidies over price supports is surprisingly large. The efficiency gains can be placed in rough perspective by noting that the minimal figure of \$33 million represents (a) roughly 40% of the total budgetary cost of the actual CDC support system, and (b) over 10% of the aggregate market value of the entire industrial milk sector. The direct subsidy advantage is even more impressive since it results from shifts in short-run resource reallocation rather than major changes in long-run production.

The efficiency gain over the actual system of aid is much more modest. The implication is that the CDC support structure at the time was far closer to the direct subsidy ideal than to its price support antithesis.

Tentative conclusions are also possible about the effect of import controls. The trial simulation for 1970-71 demonstrated that a "free-trade" system¹ would register a \$15 million efficiency gain over the direct subsidy scheme and a \$20 million advantage over the actual support program. This further increase in efficiency accrues from trade specialization--domestic milk production is devoted exclusively to the product of comparative advantage (cheese), while domestic needs for the remaining dairy products (skim milk powder and butter) are heavily met through imports. These simulation results, however, are based upon far more tenuous assumptions than the previous direct subsidy/price support comparisons. The figures are probably good enough to indicate the type of free-trade consequences, but they certainly should not be relied upon in detail. To accurately estimate such effects, it would be necessary to greatly improve the capability of the econometric model to "track" dairy industry behaviour--even in the face of major structural changes and tremendous shifts in resource allocation.

¹That is, a direct subsidy system without import controls.

It is important to note that all the comparisons of alternative support systems (direct subsidy, price support, actual CDC, and "free trade") have been made solely on the basis of the economic efficiency criterion. No consideration has been given to other kinds of policy effects (such as the distributional impact of the different schemes), or to the administrative and structural problems of implementing program changes. An adequate accounting of these (or other) program effects could possibly reverse the quantitative efficiency results. It is unlikely, however, that any combination of factors would have a differential impact large enough to offset the tremendous efficiency difference between the polar price support and direct subsidy schemes.¹

Finally some observations can be made about the relationship between the empirical results and the theoretical analysis of the paper. Despite its rather naive simplicity, the theoretical model of Chapter 4 served a very useful purpose as it correctly indicated the relative efficiency of direct subsidies over price supports. The model also accurately predicted that the size of the efficiency gap would be inversely correlated with the export price level. Nevertheless, the

¹ Indeed it is likely that the nutritional and income distributional effects of moving to a direct subsidy scheme would strengthen its advantage over both the actual and the price support systems. The price of skim milk powder would certainly drop significantly under a direct subsidy approach. Since skim milk powder has both a high nutritional value and a low income elasticity of demand, a decline in its price should have substantial beneficial effects that are not considered in the relative economic efficiency calculus.

shortcomings of such a simple theoretical tool--as argued in the introduction--have also been strongly demonstrated. The theoretical analysis was incapable of gauging the magnitude of the efficiency effect, and even some of the qualitative judgments were proven incorrect. The most glaring error was the judgment that consumers must always gain from a switch to direct subsidy support. Because of (a) the peculiar structural complications of the dairy market and (b) the particular array of export prices, demand elasticities, and production relationships, the empirical results show that in two of the three years consumers would lose in a move from the actual support system to direct subsidies. It must be admitted that this combination of special circumstances is rather unusual, yet every particular market situation has its own special oddities, and each of these would be impossible to capture without explicit empirical modeling. Policy conclusions based solely upon theory, therefore, should only be considered tentative until they are backed by detailed empirical analysis.

APPENDIX I

THE SIMULATION PROCEDURE

As stated in the text, the simulation procedure utilized in the empirical analysis of Chapter 6 consists of three general components:

- (1) adjustment of the equations in the econometric model of Chapter 5 to make them suitable for use in the policy simulation;
- (2) solution of the resulting modified equation system for the hypothetical price-quantity vectors which would have prevailed under both direct subsidy and price support systems in each of three fiscal years (1969-70, 1970-71, and 1971-72); and
- (3) calculation of the gains and losses (and the resulting net societal benefit) experienced by the four interest groups (consumers, processors, producers and taxpayers) covered by the conditions of the simulation exercise.

Each of these steps is described in detail below.

I. Adjustment of the Equation Set

For the reasons argued in the text, the simulation procedure adopted in the analysis is to compute the impact solution that would have prevailed in the first year after the hypothetical policy changes were adopted. In other words pre-determined variables, as well as exogenous variables, assume the values that are actually indicated in the historical data. This in turn requires that a different set of simulation equations be calculated for the three fiscal years.

To obtain each of these equation sets, a three-step procedure was followed. First, fiscal year values of variables not directly observable were obtained by interpolating the relevant calendar year variables. Second, the values of the exogenous and pre-determined variables for each fiscal year were substituted into the appropriate equations to obtain three preliminary equation sets.¹ Third, the observed residual error for each equation was computed using the observed endogenous variable values under the actual support scheme. Since these errors are assumed random (and in particular therefore are uncorrelated and unaffected by policy changes), the errors should be the same under a price support or a direct subsidy system. These values were therefore added to the relevant equations.²

The procedure at this point yields three corrected set of linear equations for all 18 endogenous variables described in the econometric model of Chapter 5. Many of the equations are definitional identities, there is a considerable degree of recursiveness in the system, and most equations have only two variables. All these properties make the actual solution step that much easier.

¹The definition of what constitutes endogenous and exogenous variables changes somewhat under the differing support schemes. This issue is discussed in the next section. The variables referred to here are those (e.g., P_{mrg}) which are exogenous under all support schemes.

²In other words the underlying stochastic disturbance for each equation is assumed to be independent of changes in the support structure. Therefore, the observed residual can be used as the best-guess estimate of this disturbance.

2. Solving for Simulated Price/Quantity Vector

The second stage in the simulation procedure is to solve for the six hypothetical price-quantity vectors (3 fiscal years, 2 different support systems). In order to obtain these price-quantity solutions, it is necessary to take the three overall equation sets of step one and impose on them the conditions first of a pure direct subsidy system and second of a pure price-support scheme. Each of these tasks poses some further problems.

The Direct Subsidy System

The major difficulty in simulating the direct subsidy system is deciding whether the prices of the three final products would be equal to the domestic clearing prices or the relevant export prices. Ultimately this problem had to be approached through trial and error. A combination of endogenous and exogenous price conditions was imposed, the model was solved on this basis, and the resulting solution set was checked against the original conditions for consistency. A consistent solution requires that:

- (a) if the final product price is determined in the domestic market, this price must be greater than or equal to the corresponding (exogenous) export price; and
- (b) if the final product price is determined in the export market, domestic supply must be greater than or equal to domestic demand.

The actual process of solving the simultaneous, linear equation set was somewhat arduous, but as noted earlier, was simplified by the

degree of recursiveness of the system and by the large number of definitional relationships that exist in the model.

This general procedure perhaps can be clarified by the use of an example. In particular the simulated price-quantity vector under the direct subsidy system for 1969-70 was obtained in the following specific manner. First, as was noted above, some judgment had to be made as to which of the final product markets would be in equilibrium at the domestic clearing price and which would assume the international (export) price. For 1969-70 the a priori guess was made (which eventually turned out to be correct) that P_{ch} and P_{smp} would be determined exogenously by the international market, and that P_b would be determined endogenously by the domestic market clearing condition. Secondly, the values of the predetermined variables and of the observed residual errors were substituted into the relevant equations. These steps transformed the equation system of Section 5.7 (which represents the actual support system during the estimation period) into an equation system which specifically represents the simulated direct subsidy system for the fiscal year, 1969-70:

- (1) $Q_m = 10219$
- (2) $Q_{mlk} = 6693 + 10.07 P_{sm}$
- (3) $P_m = P_{mb}$
- (4) $P_{mb} = F_{mch}$
- (5) $P_{mch} = .035 P_{bf} + .01 P_{sm}$
- (6) $Q_m = Q_c + Q_{mlk}$

- (7) $Q_{mlk} = Q_{mch} + Q_{mb}$
- (8) $Q_{bf} = Q_c + Q_{mb}$
- (9) $Q_{sm} = 8079.7 - 632.9 P_{sm}$
- (10) $Q_{sm} = Q_{mb}$
- (11) $Q_{bf} = -6956 + 1770 P_b - 1475 P_{bf}$
- (12) $Q_{mch} = 13324 - 5587 P_{mch}$
- (13) $S_{smp} = .078 Q_{sm}$
- (14) $S_b = .0427 Q_{mb}$
- (15) $S_{ch} = .0701 Q_{mch}$
- (16) $D_b = 655.8 - 6.46 P_b$
- (17) $D_{smp} = 209.5$
- (18) $D_{ch} = 165.8$
- (19) $D_b = S_b$

It should be noted that in comparison to the set of estimated equations in Section 5.7, the above set has one more equation (the equilibrium condition for the butter market) and one more endogenous variable (the price of butter). By using the definitional identities and by eliminating the variables whose values were already known, this equation set was reduced to a "working set" of ten equations in ten unknowns; specifically:

- (1) $Q_{mlk} = Q_{mb} + Q_{mch}$
- (2) $Q_{mch} = 13324 - 5587 P_{mch}$
- (3) $Q_{mb} = 8079.7 - 632.9 P_{sm}$
- (4) $Q_{mlk} = 6693 + 10.07 P_{sm}$

$$\begin{aligned}
 (5): \quad Q_{mch} + Q_{bf} &= 10219 \\
 (6): \quad Q_{bf} &= -6956 + 1770 P_b + 1475 P_{bf} \\
 (7): \quad D_b &= S_b \\
 (8): \quad D_b &= 655.8 - 6.46 P_b \\
 (9): \quad S_b &= .0427 Q_{bf} \\
 (10): \quad P_{mch} &= .035 P_c + .01 P_{sm}
 \end{aligned}$$

The solution of this reduced set was relatively simple for two reasons. First, further "collapsing" of the system was fairly easy.¹ And second, as soon as the value of one variable was obtained, the remainder of the system was recursive and other variables could be calculated easily by repeated backward substitutions.

¹For example, the system was reduced to a 4 x 4 set in three steps:

- (a) equations (2)', (3)', and (4)' were substituted into equation (1)' to yield a new equation in two unknowns (P_{mch} , P_{sm});
- (b) equations (2)' and (6)' were substituted into equation (5)' to yield a new equation in three unknowns (P_{mch} , P_b , P_{bf});
- (c) equations (8)', (9)', and (6)' were substituted into equation (7)' to yield a new equation in two unknowns (P_b , P_{bf}).

These three new equations together with equation (10) represented a system of four equations in four unknowns (P_{mch} , P_{sm} , P_{bf} , and P_b).

In a couple of more steps it was possible to solve this reduced set for the P_{mch} and then obtain the full solution vector.

Lastly, when the final solution set was obtained, it was checked for consistency (that is, to see if the initial guess regarding the relevant market clearing conditions for the final products were indeed accurate) along the lines indicated previously. In this case consistency requires that

- (i) $S_{ch} \geq D_{ch}$
- (ii) $S_{smp} \geq D_{smp}$
- (iii) $P_b \geq \text{export price of butter}$

All these conditions were fulfilled, so that the calculated solution is indeed the correct simulated price-quantity vector.

The Price Support System

The difficulties faced in solving for the price support system were definitional. First, it was not clear which price support scheme should be used. As indicated in the text, the condition of the empirical analysis requires that returns to (in-quota) milk and cream production be kept constant. In other words the prices of milk and cream in the simulated system must be equal to their observed values plus the relevant net subsidy payments. Unfortunately, there is more than one combination of the three support prices which can give this result. The procedure adopted in the simulation was to fix the price of cheese by raising its value in proportion to the desired increase in the price of milk for cheese. This eliminated the extra degree of freedom; the butter and skim milk powder prices became part of the system's solution set.

The second definitional problem was also discussed in the text. The actual support system involves a structure of levies and penalty

payments designed both to control aggregate production (particularly of milk) and to help offset surplus disposal costs. It was necessary to decide what would be done with these producer charges. The decision reached was to eliminate the within-quota levy, but to assume all penalties against over-quota production remained unchanged.

After specifying these assumptions, the three solution vectors for the price support system were easily obtained. Indeed since the prices of cheese, cream, and milk are all exogenous, the system is recursive and therefore readily solved.

3. The Net Benefit Calculations

Given the price/quantity vectors obtained in the previous step, the calculation of the aggregate net benefit was relatively straightforward and followed the procedure outlined in the text. Changes in welfare surplus were computed for each affected group based on the relevant ex ante and ex post prices and quantities.¹ The overall net benefit is the simple sum of these separate gains and losses.

More specifically, in the direct subsidy solutions the changes in welfare surplus were calculated as follows:

¹To be able to compute the change in producer surplus, one final step remained: it was necessary to know the separate supply and price effects on milk and cream quota production, non-quota production, and over-quota production. This in turn implied that the skimming-decision equation had to be disaggregated for each of these three groups. Actually, by the conditions of the simulation exercise, returns to quota producers are always kept constant, so it was only necessary to derive two additional equations. As described in the text, these equations were obtained by assuming that all classes of production responded to altered market conditions in the same way--specifically, that the price and quantity elasticities were identical.

- (1) Consumers: The change in consumers surplus was estimated for the three final products (butter, cheese and skim milk powder). In each case the change in surplus is equal to the difference between the ex ante and simulated prices times the average quantity consumed.
- (2) Taxpayers: The impact on taxpayers is the sum of four effects. The first component is the increased subsidy cost (which in turn equals the drop in milk prices times the quantity of milk produced, plus the decline in cream prices times the quantity of cream produced). The other three components are the elimination of surplus disposal and storage costs, and the loss of receipts from penalty payments.
- (3) Processors: The change in processor surplus was calculated for the three processing functions (skim milk powder from skim milk, butter from cream, and cheese from whole milk). The price used in the computations was the processor value-added. In each case the change in processor surplus was obtained in an analogous fashion to the procedure used for consumer surplus. That is, the change in surplus is equal to the difference between the simulated and actual processor value-added, times the average quantity processed.

- (4) Producers: By the conditions of the simulation, returns to quota production are unaffected by the shift in support systems. The impact on producers therefore is limited to the effect on over-quota and non-quota production of milk and cream. The change in processor surplus for over-quota milk production is equal to the drop in milk price plus the penalty quota (since this is eliminated under a direct subsidy system), times the average amount of over-quota milk produced. The change in producer surplus from over-quota cream production, and from under-quota milk and cream production was calculated in an exactly analogous fashion (except adjustments for penalty payments were unnecessary in the latter two cases).

The net benefit calculations for the price support schemes followed very similar procedures:

- (1) Consumers: The same formula for computing the change in surplus was used.
- (2) Taxpayers: The effect on taxpayers is the sum of three factors. First, subsidy costs are eliminated. This saving was calculated by taking the proportion of actual subsidy costs (in deflated dollars) which could be attributed to the three industrial milk uses accounted for by the model. During the fiscal years covered this proportion was approximately 86 percent. Second, there is an increase in the surplus disposal cost. The new surplus disposal cost was

calculated for each product by multiplying the difference between the new product support price and the export price, times the amount of surplus product. The change in disposal costs is, of course, this simulated cost less the actual disposal costs. The final effect on taxpayers is a small adjustment for changes in (over-quota) penalty revenue which arise because the relative quantities of milk and cream shipped are different under the simulated price support scheme.

- (3) Processors: The impact on processors was calculated in the same way as in the direct subsidy estimates.
- (4) Producers: For both over-quota and non-quota production, the change in producers' surplus was calculated as the change in the price of milk (or cream) times the average quantity produced. (Since the penalties for over-quota production are assumed to remain the same under a price support system, only the change in market prices need be accounted for in the calculations.)

APPENDIX II

RECENT DAIRY POLICY DEVELOPMENTS.

The analysis of this paper focuses on the dairy support policies in effect during the period 1969-72. Because of the institutional and structural changes discussed in the text, the empirical analysis cannot be extended easily to the years since 1972. Nevertheless it is possible to sketch in broad outline the major policy evolution that has occurred in the intervening years and then to make some preliminary judgements about the relevance of the present theoretical and empirical analysis to current policy issues.

The most significant development has been the gradual, but nonetheless marked, movement toward a third type of support system-- supply management.¹ Under the supply management approach support would be provided (in the long run) by a price support structure, with direct subsidies fixed in nominal terms and hence declining in real terms over time. The major difference between the price support and supply management approaches is that the latter also involves the active manipulation of the market share quota (MSQ) system to

¹The supply management policy has never been completely and fully articulated. However, the general philosophy has been expounded in numerous statements by both the Minister of Agriculture and by the Canadian Dairy Commission. The philosophy is also strongly evident in numerous program decisions including the announcement of the "Long Term Dairy Policy" by the Minister on April 18, 1975, and the annual CDC changes in the support levels and operation.

enforce control over quantity, as well as price. The goal of the MSQ intervention has obviously been to reduce substantially the amount of excess supply that occurs at the administered support price levels-- in other words to move up the demand curve without causing surplus disposal problems. Control over production has been exerted in a number of ways including limiting the percentage of MSQ production on which subsidy is paid, and charging a prohibitive levy (at times amounting to close to one hundred percent of the market price) on all production in excess of MSQ. A major pronounced goal of the government in the movement to a supply management system has been to lessen the budgetary cost of the support program and to force more of the dairy producers' income to come "from the market".¹

In terms of the analysis of this paper, two comments can be made about the adoption of the supply management scheme. First, the use of quantity controls can be viewed as a method of minimizing the aggregate welfare losses that occur under a price support system without quantity controls when export prices are very low. Welfare losses will still exist (in comparison to a direct subsidy system), but they should be substantially less under a supply management scheme.²

¹It should be noted that it has not proved politically feasible to accomplish this goal so far. Indeed budgetary costs for the subsidy program currently run well in excess of \$300 million a year-- approximately triple their (nominal) level at the end of the simulation period (1971-72) covered by the study.

²In the case of the simple theoretical model of Chapter 4 (Figure 3, p.28), an idealized supply management system would hold welfare losses to triangles BHI plus IHK, eliminating the (potentially substantial) extra losses of triangle DEF and the remainder of rectangle EIKL.

In this context it is interesting to note that most of the active moves toward the implementation of a supply management system occurred during a period (1975-77) when export prices fell rapidly from formerly high levels.

Second, for a supply management system to operate smoothly, the exercise of simultaneous price and quantity controls presumes a substantial ability to anticipate and correct for both shifts in demand/supply conditions and spillover market effects caused by past and current policy changes. The nature of the empirical model of Chapter 5 indicates the complex interdependent nature of dairy markets. In particular there is considerable interdependence among the various product markets. The real world situation is even more complex (more alternative industrial milk products, more complicated relationship between the fluid and industrial sectors, and additional influences of provincial regulatory policies). Unless all these complications are accounted for in the formulation of the price and quantity restrictions, the market disruptions and inefficiencies could be even greater than a simple comparative static analysis of the supply management scheme would suggest. The empirical model cannot prove that such disruptions will occur, but its structure suggests strongly that the implementation of a supply management scheme can be fraught with many difficulties.

APPENDIX III

DATA SOURCES

The data for the econometric model of Chapter 5 were obtained from the following sources:

Input Quantities

- (1) Q_m : obtained as the sum of Q_{mch} and Q_{bf}
- (2) Q_{mch} , Q_{bf} : Statistics Canada, Dairy Statistics, 23-201, annual (henceforth DS).
- (3) Q_{sm} : obtained from the identity,

$$S_{smp} \equiv .078Q_{sm}.$$
- (4) Q_{mb} : obtained from the identity,

$$Q_{sm} = Q_{mb}.$$
- (5) Q_c : obtained from the identity,

$$Q_{bf} = Q_c + Q_{mb}.$$
- (6) Q_{mlk} : obtained from the identity,

$$Q_{mlk} = Q_{mb} + Q_{mch}.$$

Output Quantities

- (7) S_b , S_{smp} , S_{ch} : obtained from DS (production of the relevant commodity).
- (8) D_b , D_{smp} , D_{ch} : obtained from DS (domestic disappearance of the relevant commodity).

Input Prices

- (9) P_{mch} , P_{mb} , P_{bf} : DS
- (10) P_m : obtained from the arbitrage condition,

$$P_m = P_{mb}.$$

(11) \bar{P}_{sm} : obtained from the identity,

$$\bar{P}_{mb} = .01\bar{P}_{sm} + .035\bar{P}_{bf}$$

Output Prices

(12) $\bar{P}_b, \bar{P}_{ch}, \bar{P}_{smp}$: obtained from DS (1969-71) and from
I. F. Furniss, Selected Statistics of the
Canadian Dairy Industry (1958-68).

Exogenous Variables

(13) \bar{P}_{MRG} : obtained from Statistics Canada, Prices and
and Price Indices, 62-002, (1969-71),

I. F. Furniss, op. cit., (1958-68).

(14) \bar{Y} : obtained from Bank of Canada, Statistical
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