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THE CANADIAN COMPONENT OF THE IIASA WORLD FOOD MODEL

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FOREWORD

Understanding the nature and dimensions of the world food problem and the policies available to alleviate it has been the focal point of IIASA's Food and Agriculture Program (FAP) since it began in 1977.

National food systems are highly interdependent, and yet the major policy options exist at the national level. Therefore, to explore these options, it is necessary both to develop policy models for national economies and to link them together by trade and capital transfers. Over the years FAP has, with the help of a network of collaborating institutions, developed and linked national policy models of twenty countries, which together account for nearly 80 percent of important agricultural attributes such as area, production, population, exports, imports and so on. The remaining countries are represented by 14 somewhat simpler models of groups of countries.

A separate national model of Canada, which is a major agricultural trader, is included in our system of linked models. Several different approaches to model Canadian agriculture were tried out and compared with the help of Canadian specialists from the University of British Columbia and Agriculture Canada. John Graham, H. Bruce Huff and Ralph G. Lattimore have described these approaches and compared them in this paper.

This working paper is one of a series of Working Papers documenting the work that went into developing the various models of FAP's system of linked models.

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BACKGROUND

The International Institute for Applied Systems Analysis (IIASA) is funded by the academies of science of 17 different nations. The objectives of the Institute are twofold:

1. The promotion of international collaboration by bringing together scientists of different nationalities and disciplines,
2. To contribute to the advancement of the sciences and systems analyses and an application of these two problems of international importance.

The Food and Agriculture Program (FAP) at IIASA has as its objective an evaluation of the nature and dimensions of the world food situation over the next 10 to 15 years. It aims to identify factors affecting the world food situation by studying the growth processes of different countries and how national policies of both developed and developing nations impact on the situation. The research strategy is to develop economic models of about 20 different countries, to link these through international trade and then to study their economies and growth processes. It is recognized that the world food situation can best be studied by considering the programs and policies of individual nations and it is these policies and the resources and technologies of each of these individual nations that will in the long run determine production capacities. On this basis research teams from different nations have assembled and are developing national economic models which are linked through international trade. The completed system will allow for an evaluation of national and global policy alternatives as they relate to food problems and other economic issues.

Countries currently included in FAP's model system were selected according to two criteria. First, together they comprise about 80 percent of the world's population, land base, agricultural production and the exports and imports of agricultural products. A second consideration was that countries included be both from developing and developed categories, and as a consequence most of the important countries from a trade point of view are included.

1.1 The Linkage System and Commodity Aggregation

The development of a work program and the computational requirements for a linked international trade system have resulted in certain basic requirements being stipulated for each of the countries involved:

1. Commodities to be traded by all countries should follow a common commodity classification (i.e., 18 agricultural and 1 nonagricultural).
2. A country's import and export requirements for each of these are a function of world commodity prices.
3. Import and export requirements are generated on a yearly basis and a country's supply of a commodity is a function of prices for the previous year. The world price is determined by equating domestic demands and fixed supplies for each of the traded commodities.

These requirements imply that each model be closed in the sense that the total economy is considered, that the model be recursively dynamic because total world supply is predetermined and the models operate in one-year increments over a 10 to 15 year time horizon. No restrictions are placed on the estimation procedures adopted by different participating countries. Both mathematical programming and econometric methods are currently being used. Table 1 indicates the commodity classification considered for traded goods. Two levels of aggregation are noted with the detailed commodity classification representing the final goal. Currently some models have been disaggregated to this level, while other national economies are represented at the more aggregated level.

Different countries will use different policy instruments for many of the commodities indicated and the effects of these as they influence both national and international trade prices may be examined using the linked system of national models. Production and trade alternatives, changes in production structures and income redistribution alternatives (important for many countries) may also be investigated by interested policy makers. The system of linked national models also permits an evaluation of a number of international policy issues. For example, the workings of an international buffer stock agency or the effects of international food transfers may be examined.

1.2 Existing Country Models

Countries included in FAP's programs represent over 80% of the world's population, agricultural production and trade (See Table 2). National models of the U.S.A., Japan, the European Economic Community and Canada represent the most important trading nations. Amongst the

Table 1. Commodity List at the Detailed and 9 Commodity Level

Condensed Model			Detailed Model		
No.	Commodity	Unit of Measurement	No.	Commodity	Unit of Measurement
1	Wheat	10 m.t.	1	Wheat	10 m.t.
2	Rice, milled	10 m.t.	2	Rice, milled	10 m.t.
3	Coarse grain	10 m.t.	3	Coarse grains	10 m.t.
4	Bovine and ovine meats	10 m.t. (carcass weight)	7	Bovine and ovine meats	10 m.t. (carcass weight)
5	Dairy products	10 m.t. fresh milk equiv.	10	Dairy products	10 m.t. (prot. equiv.)
6	Other animal products	10 m.t. (prot. equiv.)	8	Pork	10 m.t. (carcass weight)
			9	Poultry & eggs	10 m.t. (prot. equiv.)
			13	Fish	10 m.t. (prot. equiv.)
7	Protein feeds	10 m.t. fresh milk equiv.	5	Protein feeds	10 m.t. (prot. equiv.)
8	Other food	mill. US$(1970)	4	Oils and fats	10 m.t. (oil equiv.)
			6	Sugar products	10 m.t. (ref. sugar)
			11	Vegetables	mill. US$(1970)
			12	Fruit & nuts	mill. US$(1970)
			14	Coffee	10 m.t.
			15	Cocoa, tea & their products	mill. US$(1970)
9	Nonfood agriculture	mill. US$(1970)	17	Clothing fibres	mill. US$(1970)
			18	Industrial crops	mill. US$(1970)
10	Nonagriculture		19	Nonagriculture	mill. US$(1970)

Table 2. Percentages of World Population, Production of Agricultural Commodities, Land Base, and Agricultural Trade in 1976[a]

Country	Pop-ulation	Pro-duction	Land base	Imports	Exports
		Percent			
US	5.3	12.3	9.8	8.07	8.85
Australia	0.3	1.6	1.3	0.25	5.00
New Zealand	0.1	0.5	0.1	0.14	2.09
Canada	0.6	1.2	2.0	1.99	3.25
EC	6.4	11.9	3.3	38.83	26.05
Japan	2.8	1.8	0.4	8.36	0.05
Austria	0.2	0.4	0.1	0.62	0.31
Sweden	0.2	0.3	0.2	1.13	0.42
Finland	0.1	0.2	0.1	0.42	0.25
CMEA	9.0	16.7	17.5	12.72	5.74
Sub-Total	25.0	46.9	34.8	72.53	62.01
Pakistan	1.8	0.9	1.4	0.34	0.34
China	21.4	13.2	17.3	1.64	1.81
Nigeria	1.6	0.5	1.6	0.50	0.40
Argentina	0.6	2.0	1.7	0.14	2.86
Indonesia	3.4	1.6	1.5	0.64	1.02
Turkey	1.0	1.6	1.6	0.14	0.96
Mexico	1.5	1.5	1.3	0.35	0.82
Thailand	1.0	1.1	1.1	0.18	1.23
Brazil	2.8	4.7	4.0	0.75	5.55
Bangladesh	1.9	0.7	1.1	0.34	0.11
Egypt	1.0	0.7	0.3	0.94	0.56
India	15.5	6.7	14.6	1.06	1.30
Kenya	0.3	0.2	0.2	0.06	0.33
Sub-Total	53.8	35.4	47.7	7.08	17.29
Total	78.8	82.3	82.5	79.61	79.30

developing nations one finds Bangladesh, Brazil, Indonesia, Kenya, Nigeria and others. China and the CMEA countries are also included.

The research effort involved in attempting to model each of these countries is enormous. Initially, a specific group of countries were selected and modeled: the European Economic Community (a developed, nearly self-sufficient market economy), India (a developing market economy with nutritional problems) and Hungary (a centrally planned economy with a food surplus). The detail involved in these models is at the 19-commodity level of disaggregation and particular attention is paid to representing the structure of these economies as accurately as possible. Research teams from institutions for each of these countries were responsible for model development.

A second stage of the program has involved the development of "simplified" models for most of the countries indicated in Table 2. The level of aggregation for these is at the 10-commodity list and the strategy involved is to replace these simplified country models with detailed country models as soon as these are developed and validated. One may study international trade effects because a framework for doing so is available and as detailed and validated country models are developed the entire model framework becomes more accurate and reliable. These simplified country models therefore represent an intermediate study in the evolution of the research program; they successfully incorporate the major structural components of the economy of each country but the detail is lacking. Policy aspects are generally ignored as are some other important components.

In the development of each of the detailed models it is FAP's policy to attempt to involve local expertise and local institutions. An international network of modeling groups was established and these groups work closely with FAP. Detailed models for the following countries are currently under development: Austria, Brazil, Bangladesh, China, CMEA, EC, Egypt, Japan, Kenya, Thailand, the U.S.A. and Canada. There are countries also collaborating with FAP and not included in the original group of 20. Included are Finland, Poland and Turkey, where local institutions are developing detailed national models. Collaboration is still required from Argentina, Australia, Indonesia, Mexico, New Zealand, Nigeria and Pakistan in order to complete detailed models from these countries. It should be noted that in some of these countries detailed agricultural models have already been developed and it is merely a matter of making the required resources and funds available in order to achieve consistency and linkage.

Hence, the long-run working program calls for detailed country models to be developed and maintained by national research institutions. The international linkage system will provide a solution algorithm for traded items in one-year increments over a 15-year planning horizon. Long-run trends in the world prices for each of the traded items are given and these relative prices may be used as information in the planning processes for each of the countries involved. The program emphasizes the role that national policies play in determining the direction of growth for each national economy and the effect of these growth patterns on international trade.

The development of a Canadian model within the IIASA world food model system is viewed as a cooperative effort of advantage to all. Each country would have access to methodological expertise of IIASA and participate in the linking of the Canadian model with other country models. In the development of the Canadian model some specific institutional information and policies are incorporated. An attempt has been made to develop a functioning model capable of providing information on some of the issues mentioned above.

1.3 The Work to Date

A typical FAP general equilibrium type model will generally consist of four important components or sectors -- the agricultural supply module, the nonagricultural sector, the government sector and a demand module. This report covers work attempted for the agricultural supply sector only; the remaining components will be covered separately.

In the section that follows some Canadian policy issues are addressed that a model of the FAP type may attempt to incorporate. It is argued that national policies determine and influence production patterns in individual countries and consequently these issues must be addressed and incorporated into the structure of the proposed model framework. Following this, details of the basic linked model (Canadian) as developed by Fischer and Frohberg (1980) are presented. As a starting point in the development of a more detailed Canadian model it was useful to examine this model. As well, a more refined version is presented attempting to overcome some of its shortcomings. Another alternative specification is based on a standard econometric modelling approach. Finally, the report details some of the difficulties encountered in linking domestic prices to those of the world.

2. POLICY CONSIDERATIONS

National policies as implemented by a government of a country are of critical importance in the FAP model system. After all, it is such policies that determine agricultural production patterns in a country and ultimately world trading patterns (Parikh, 1981). On an ex post basis the FAP model covers the period 1961 to 1980. On an ex ante basis a 10-15 year horizon is appropriate. Given these requirements it is necessary to attempt to conceptualize an agricultural model that adequately incorporates past and possible future policies in some manner. Many policies are commodity- or region-specific, they are operative for time periods of varying length, they are implemented by differing levels of government and their impacts have differed. It is also important to try and anticipate some future policy directions and attempt to incorporate some of their components into the structure of the model developed. Within an international setting some policies that may be analyzed have been outlined by Parikh (1981). In this section of the paper we briefly outline in a general manner Canadian policy aspects of interest. Futher details concerning policies directed at specific commodities are noted in Section 3.

2.1 Earlier Policy Developments

Menzie (1980) in reviewing the development of Canadian agricultural policy over a 50-year period (1929-1979) concluded that policies that have emerged have indicated a consistent and basic theme. Farmers have struggled for greater bargaining power and one result has been national marketing boards. Farmers have sought improved price and income security and this has also been obtained through the actions of various producer marketing boards and through income stabilization legislation enacted both by provincial and federal governments.

In 1979, there were more than 100 marketing boards in Canada handling over 50 percent of all agricultural sales. Marketing boards exist for grains, milk, poultry, pork, fruit and vegetables. Several of the boards are national in scope while others are provincial. Their role varies from mere promotion to a more controlled situation where both market prices and production quotas are set. The Canadian Wheat Board established in 1935 was given full control over commercially marketed wheat in 1943. This policy has continued to the present time -- its impact on the entire agricultural industry, upon the total Canadian economy and to a certain extent on the international market for wheat cannot be ignored.

Concerns about income stability and low farm incomes relative to nonfarm incomes have also resulted in policies directed to this end. During the 1940's and early 50's price supports were provided. In 1958 the Agricultural Stabilization Act was passed, whereby prices for nine commodities were to be maintained at 80% of the previous 10-year average price - payments under this program were fairly small. More recently (1975) stabilization legislation supports prices at 90% of the average market price over the past 5 years adjusted for changes in cash production costs. Commodities covered include industrial milk and cream, beef cattle, hogs, sheep and lambs, corn, soybeans and oats and barley grown outside the designated Canadian Wheat Board area. Also, under the Western Grain Stabilization Act grain producers receive payments when receipts drop below the previous five-year average adjusted for changes in production costs. Crop insurance programs also operate and in addition in many provinces operate stabilization programs.

Aside from these major policy initiatives there are obviously other measures that influence agricultural growth and productivity and there are also policies directed at income equity and the urban population. Farm credit programs, agricultural extension and research programs, the Agricultural Rehabilitation and Development Act of 1961, various marketing programs and others have all influenced the direction agriculture has taken. In the conceptualization of the model presented an attempt has been made to incorporate these components. Particular attention is given to the role of price formation as influenced by marketing boards and the role played by the Canadian Wheat Board.

2.2. Current Policy Issues

Current federal government policies and programs have as their objective the attainment of efficiency, growth, equity and food quality in the agriculture-food system. It is highly likely that these objectives will not change in the near future. Given this very broad categorization, some specific programs have been developed to promote these goals. Included are such activities as the promotion of agricultural research, research and development incentive programs for secondary industries, market information programs, export market development services, agricultural stabilization programs, trade and tariff measures and so forth. The interdependence between sectors and between the different levels within a sector as these programs are developed must be recognized and information is required on the distribution of these benefits by region, by type of producer, by size of farm, by participant in the agricultural food chain and so forth.

It is possible to detail some of these policies as set out in a report on agricultural development strategies to the Ministry of State for Economic Development. Seven areas affecting development are indicated. It would also seem necessary to attempt to incorporate most of these aspects in the model developed and an analysis of these issues should also be attempted.

1. Research and Development

Technological change has played a key role in freeing labor resources for use in other sectors, in allowing products to be competitive in world markets, in keeping food expenditures low relative to income and in improving the quality and variety of food products. In the primary agricultural supply sector basic and applied research, and the transfer of these results to the operating farm level, will continue to receive high priority. It may be expected that over a 10 to 15 year horizon some fairly significant changes may occur. Northern agriculture is being considered, there are scientists debating the merits of summerfallow, new lower grades of wheat offer potential for expansion in yields, there is increased irrigation, drainage and snow control, there are programs aimed at the prevention of soil degradation through salinization, compaction and erosion, there are projects examining energy-reducing methods and so forth. The impact of these programs will vary by commodity. It would be extemely useful if this project could provide information on some of these more specific research programs. The benefits and costs involved in these developments are important.

2. Market Development

Growth in the Canadian domestic food market is limited by relatively stable per capita food demand and by low rates of increase in population. Income growth obviously allows for an expanded market, particularly for those high quality food products with high income elasticities (e.g. meats or food away from home). Also of high priority is the development of export markets, particularly for the grains and livestock sectors. The Wheat Board sales policy has tended to concentrate on traditional markets and high-quality wheats, but increasingly evidence is there that the market for lower grade wheat and the markets in developing countries are growing most rapidly. Programs which encourage an efficient and market-oriented production-processing-distribution system are critical. Efficiencies to be gained from a liberalization of trade are also important and are expected to receive priority in trade negotiations. It would of course be useful to measure welfare losses associated with these barriers and in the longer run measure the gains that countries may experience if some of these barriers are reduced. On the other hand, it has also been argued that a stable domestic market is required to protect certain agricultural sectors at certain times from low cost imports, especially when these result from agricultural and trade policies of the exporting countries involved. Again, these are important policy issues for which the IIASA model framework may provide some insights.

3. Market Stabilization

Fluctuations in agricultural commodity supplies and prices are of concern because of the high investment costs associated with many farming enterprises. Agricultural policies aimed at countering this variability include price and income assurance policies, supply management policies and trade policies. Questions may be raised whether the balance among these three aproaches is effective and whether a proper emphasis between income and price stability versus other goals is achieved.

Under the Agricultural Stabilization Act and the Western Grain Stabilization Act payments are made to producers when market price of a commodity, adjusted for cash production costs, falls below the average for the base period. The program obviously aims at protecting producers against violent swings in the market. It tries to avoid distorting underlying supply and demand relationships and it also attempts to preserve regional comparative advantages. The concern in the administration of such programs is to avoid introducing rigidities and excessive profits into the system and yet maintain stable production and adequate incomes for producers. The interests of all sectors including producers, processers, distributors, retailers and consumers need to be considered. Where quotas exist, questions arise as to how existing or new quotas may be reallocated between regions in accordance with changes in regional comparative advantages and in ways to meet regional and national economic development objectives. It is also important to ensure that productivity gains are always transferred to the market.

On the supply management side, industrial milk and poultry products are covered at the federal level; there are also a few commodities managed at the provincial level. The Canadian Wheat Board through the use of delivery quotas also controls the flow of wheat, oats and barley to the market. Under the General Agreement on Tariffs and Trade a country may establish import quotas to protect domestic supply management programs. Therefore, for these commodities controls on imports exist.

Turning to trade measures, temporary tariff surcharges have been used to protect domestic producers from temporarily depressed international markets and when domestic production falls short imports are negotiated. Canada is also involved in a continuing effort to stabilize world grain markets through some form of price-buffer stock management.

4. Regional Development Programs

With the development of the energy industry in the Western provinces some fairly dramatic regional growth changes are currently taking place in Canada. Questions are raised as to how the development of the primary and secondary industries should be directed. At the federal level such plans involve the Department of Regional Economic Expansion, the Department of Industry, Trade and Commerce and Agriculture Canada. A development strategy providing for efficiency, growth and equity between regions is obviously desirable but devising programs to achieve this balance is also difficult. A regionalization of the model may be desirable.

5. Infrastructure

An efficient agriculture also requires a well developed infrastructure. A major current concern in Canada relates to the transportation and handling system of grains. How to increase this capacity and how to deal with problems arising from the Crows' Rate agreement are being debated and solutions are being sought. In addition, there is the need to design a system that has the capacity and flexibility to meet the needs of a wide range of demands - grains, livestock and meat products, horticultural and fish products and processed foods both for domestic and export markets. There are other issues related to infrastructure - the growth of these and their rate of development is dependent upon expected long-run growth trends in each of the many sectors considered within the IIASA framework.

6. Factor Supplies

There are several programs which affect input supplies and prices. Included in these are taxation policies, labor and credit programs, environmental regulations affecting certain inputs, land and water programs, energy policies and so forth. Also related to these considerations are the effects of rapidly increasing costs of capital, of labor and of energy and the manner in which these changes affect the competitive position of Canadian Agriculture.

7. Structure, Conduct and Performance

The present structure of the agriculture-food system is characterized by a large number of family-operated farms, a relatively few large food processing firms, many of which are foreign-owned, and some smaller processers, a small number of relatively large retail food chains, a fairly rapidly growing food service and restaurant business, intermediary marketing and distributing firms and various institutions including cooperatives, marketing boards and other government marketing agencies. It is extremely difficult to decide on some desired mix for this system, but it is certain that various government policies affect each of these many sectors differently. Take for example farm structure - a question often raised concerns size efficiency as it relates to the family farm. The typical farm requires a large investment and this makes entry into the farming business difficult and also makes tansfers from one generation to the next a problem. The issues and the degree to which programs should favor either larger or smaller farms and how beginning farmers can enter the business are important. Another question at the processing level concerns the most efficient size of enterprise, the degree of concentration in certain markets, and the degree of foreign ownership. This structure is important in that both farm producers and the final consumer are affected accordingly.

This section has detailed some of the past and current Canadian agricultural policies. In doing so some important model conceptualization issues are noted. It is of course impossible to incorporate all of the considerations mentioned within the framework of the model developed but an attempt must be made to incorporate the more important of these. Issues which we view as currently being of lower priority will be tackled as resources permit. It is also recognized that there are certain issues that can only be handled in a model framework very different to that which we have specified or perhaps cannot usefully be tackled with given methodologies. The model detailed in the next sections is highly aggregated and not regionalized and consequently these limitations are noted. As development continues it is hoped that a more useful policy analysis tool will result.

3. THE AGRICULTURAL SUPPLY SECTOR

A major task in the development of a model of the economy is that of adequately representing the farm supply sector. Several components of the work are reported on in this section. Initially the agricultural supply sector of the Canadian model developed by Fischer and Frohberg (1980) as part of their basic linked system is examined. Based on this evaluation a revised allocation model following the same methodology is described and some of the inputs required for this revised model are detailed. We also present an alternative model based upon standard econometric methodology. We also point to the difficulties involved in the hope that these experiences may be useful knowledge to others involved in the FAP task.

Until detailed models for the various countries are developed and linked, FAP relies upon the country models developed by Fischer and Frohberg (1980). This set of country-specific models referred to as the "basic linked system" forms an extremely important component of the entire program because at this stage detailed country models developed by researchers from a particular country are few. In fact, it is only models of India, the U.S.A. and Thailand (see Table 1) that have been developed independently and are currently linked. Work on other countries continues, but it is highly likely that because of the difficult task that, in the near future, this number will remain small. For this reason it is important that one understand the methodology and structure of the basic linked models. It should also be noted that work on these basic linked models continues and many modifications have been made since the time of this writing.

Aside from the task of developing more detailed country models the FAP program requires that once developed these models be current and maintained on the system at IIASA. In the linked runs various scenarios will be analyzed. Because of the different methodologies involved in these detailed country models and because of various statistical and computational problems that are likely to arise when these analyses are attempted (even if this analysis is attempted after extensive testing) it is expected that difficulties will be encountered -- particularly so in situations where those or their replacements who developed the work are no longer resident. The expertise at IIASA can minimize these problems but these considerations have influenced our research agenda. We, therefore, considered it essential to evaluate and test the Canadian basic linked model because this model since this model will remain linked until an alternative more detailed model developed by the writers or others is substituted. Furthermore, in the development of a more detailed supply module there is much to be gained from following the same methodology as that used for the basic model system, and now currently being used for the EEC countries. We report on this work by presenting the structure of the basic linked model, a revised allocation model that was specified and estimated, and we also report on some of the results for an econometric specification of the agricultural supply module. Some of the problems encountered in all three approaches are noted.

The time horizon was divided into three important periods. For estimation purposes our time series base covers the years 1961 to 1976. The period 1977 to 1981 may be used for <u>ex post</u> forecasting and the period 1981 as an ex ante forecasting period. The ex post forecasting period (1977 to 1981) provides a rather severe test of some of the results.

3.1 The Allocation Model of the Basic Linked System

The model developed by Fischer and Frohberg (1980) for Canada is termed an allocation model because it is a nonlinear optimizing model with a nonlinear criterion function and linear inequality constraints. The constraints of the model involve an allocation of total capital, total agricultural labour and fertilizer between 8[1] alternative agricultural activities. This section highlights some of our findings of this model. More detailed reports of the model itself and the findings are available (Fischer and Frohberg, 1980; Graham and Huff, 1980; Rabar and Huff, 1980).

3.1.1 Structure

The approach followd by Fischer and Frohberg in developing their basic linked models is fairly unique. The concept of a nonlinear maximization model is not new, but its application as a tool to model the agricultural sectors of many different countries is fairly unique. Since these models are to be used over a 15 year forecast period, their validity is critical. The approach adopted is to estimate nonlinear production functions of a Cobb Douglas type for 8 fairly aggregated commodities.

[1] The agricultural commodities shown in Table 1. Bovine and dairy production is a joint product.

With a given set of coefficients for each of these production functions a nonlinear optimizing model is then solved and the optimum output levels for each of the 8 activities obtained. These output levels are then the predicted production level for that particular commodity for that year. Inputs into the agricultural sector for a particular year are agricultural capital, labour and fertilizer (for crops) and it is these limiting resources that are allocated between the 8 alternatives. Since it is optimizing model an allocation of resources between alternatives is made on the basis of expected profit per unit for each of the activities. The allocation model algorithm was developed by Fischer specifically for this particular problem, but a more generalized algorithm may also be suitable.

The approach adopted in estimating the parameters of the production functions is fairly unique. Essentially, in estimating a production function for a number of different agricultural commodities one attempts to specify the relationship between a set of inputs and outputs. Cross sectional or time series data are required. A major problem encountered for this model is that the levels of inputs are not observable. Total input levels are known but an allocation of these between alternative commodities or outputs is unknown. Furthermore, over time total input levels change and a reallocation between outputs is also likely. In fact, to cater to the time dimension aspects of the problem, several changes are made. Firstly, the constraints of the allocation problem change because over time changes in the agricultural labour force and the stock of capital invested in the industry occur. The agricultural labour force over the historical period has generally declined whereas capital stocks have steadily increased. The levels of these inputs need to be predicted over the 15 year forecast period and their allocation between alternatives decided. Secondly, to allow for certain technical changes that are taking place, the parameters of the estimated production functions are time variant.

The production relationship between inputs and the commodities is unknown. Estimates of total agricultural capital, labour and fertilizer usage are available, but an allocation of that capital to each of the major agricultural commodities is not. Estimates of these allocations can be made, various agricultural censuses may provide insights, various allocation rules may be devised, but ideally if production functions are to be estimated observations on commodity specific input levels and prices are required. In mixed farming operations or for joint commodities an allocation of resource inputs to commodities is difficult, but aside from these problems, no observations on the amount of labour, capital and fertilizer used in the production of each of the 8 commodities is available for Canada, or more generally for the other countries concerned. The approach adopted has been to devise rules that provide an initial allocation of resource use between commodities over 16 years (1961-1976). Given these observations the parameters of the production functions have been derived. With these given parameters the allocation model is solved and optimal output levels over the historical period obtained. For the 16 year period these optimum output levels may be compared with observed or actual output levels for the economy and the deviations noted. Solution of the non-linear maximization problem will also provide an allocation of the limited resources between commodities over the 16 years. Since the initial allocation of resources between commodities may be considered a starting point, Fischer and Frohberg compare observed and optimum output levels for each of the 8 commodities over 16 years to see whether this initial allocation of resources provided production function parameters that allowed the deviation between observed and optimum output levels to be reasonably small. Initially, in most instances, this is not the case and therefore, a revised set of production function parameters may be estimated. In doing so the allocation levels of resources between commodities as provided by the solution of the nonlinear programming problem are relied upon. A new set of production function parameters is obtained, the allocation model may be solved over 16 years for this new set, optimum output levels are obtained and a new set of allocations of resources between commodities obtained. The deviations between observed and optimum output levels are noted. Given the deviations a decision is then made whether to iterate once more or not. Iteration will generally continue until there is no significant improvement, using certain criteria: the coefficients of the production functions are relatively stable, the optimum output levels remain relatively stable, and the deviation between observed output levels and optimum output levels are relatively small. These coefficients of the production functions will be used to project over the 15 year planning horizon.

With this background we now report on some details of the basic allocation model, some of the results obtained and some changes that may be made if the agricultural sector of Canada is to be more closely represented.

The commodities treated in the allocation model have been aggregated to the following eight categories:

- wheat (mil. tons)
- rice (mil. tons)
- coarse grains (mil. tons)
- bovine and ovine production (beef and dairy mainly - mil.tons carcass weight and milk equiv.)
- other animals (pork, poultry and fish - mil.tons protein equiv.)
- other foods of crop origin (mil. U.S.$ 1970)
- nonfood agricultural crops (mil. U.S.$ 1970)

The constraints of the model allocate capital, labour and fertilizer to the different uses and do not exceed the total availability thereof. Output of each of the commodities ($\tilde{Y}_{it}$) is a function of the resource inputs into that commodity. This relationship between production (output) and resource inputs for crop commodities is given as:

$$\tilde{Y}_{it} = \nu_i * (K_t^A)^{\varepsilon_{it}} * (L_t^A)^{\delta_{it}} * (F_i^A)^{\rho_i} * \left(\frac{K_{it}}{K_t^A}\right)^{\gamma_i} * \left(\frac{L_{it}}{L_t^A}\right)^{\beta_i} * \left(\frac{F_{it}}{F_t^A}\right)^{\eta_i}$$

for $i \in$ crop production activities

with $\delta_{it} + \varepsilon_{it} + \rho_i = 1$; $\varepsilon_{it}, \delta_{it} = f(t)$, $i \in$ crop product

and $\gamma_i + \beta_i + \eta_i < 1$, $i \in$ crop product

and where

K_t^A = the capital stock in all of agriculture in year t

K_{it} = the capital stock employed in the production of commodity i in year t

L_t^A = the labour force in agriculture in year t

L_{it} = the labour force used on commodity i in year t

F_t^A = the nitrogen fertilizer used in all of agriculture in year to

F_{it} = the nitrogen fertilizer used on crop i in year t

For animal products in which nitrogen fertilizer is not directly used it is appropriate to specify that only capital and labour employed influence output. The production relationship for bovine and ovine production and for the other animal category is expressed as:

$$\tilde{Y}_{i,t} = \nu_i * (K_t^A)^{\varepsilon_{it}} * (L_t^A)^{\delta_{it}} * \left(\frac{K_{it}}{K_t^A}\right)^{\gamma_i} * \left(\frac{L_{it}}{L_t^A}\right)^{\beta_i} \quad \text{for } i \in \text{animal products}$$

with

$$\delta_{it} + \varepsilon_{it} = 1$$

$$\varepsilon_{it}, \delta_{it} = f(t) \qquad i \in \text{animal product}$$

and

$$\gamma_i + \beta_i < 1 \qquad i \in \text{animal product}$$

Both of the above production relationships may be rewritten such that the total agricultural capital, labour and fertilizer variables are incorporated into the intercept term. Doing so for the first equation only, the relationship is given as:

$$\tilde{Y}_{it} = \alpha_{it} * K_{it}^{\gamma_i} * L_{it}^{\beta_i} * F_{it}^{\eta_i}$$

where

$$\alpha_{it} = \nu_i * K_t^{A(\varepsilon_{it}-\delta_i)} * L_t^{A(\delta_{it}-\beta_i)} * F_t^{A(\rho_i-\eta_i)}$$

The intercept term (α_{it}) in this relationship depends on total agricultural capital, labour and fertilizer and the individual response for each of the commodities is dependent on α_{it} and upon the levels of resource use allocated to each of the commodities.

A closer examination of equation 5.10 (Fischer and Frohberg, 1980) in the basic linked system indicates that for wheat, rice and coarse grains expected total revenue is the product of the expected price per unit and output level. For the animal product production alternatives total revenue includes not only the value of the product itself, but an allowance is also made for byproducts (hides and skins, fats, etc.) and the cost of feeds used in the production process are subtracted. For protein feeds the value of the product includes the value of meal to be used as feed and the value of the oil product produced. Fairly elaborate rules were devised in order to provide these byproduct coefficients as reported in Fischer and Frohberg (1980). Difficulties were encountered in devising a satisfactory procedure to follow.

As noted, for the functions presented K_t^A, L_t^A, and F_t^A are observable over the historical period; K_{it}, L_{it} and F_{it} are not. The iterative procedure described earlier is followed, thus providing a set of production function parameters. With the coefficients of the production function given (they vary with time) the allocation model is used in ex ante forecasting.

In the following section some results of different simulations using the basic linked model developed for the Canadian situation are reported. By examining supply responses to various price scenarios it was possible to test the sensitivity of the model and the allocation procedure.

3.1.2. Model Results

The model was used for a 15-year simulation for the period 1970--85. World prices were set exogenously at actual levels for the period 1970-75, and then held constant over 1975-85. The results of this simulation for the base situation are reported in Table 3.1. In general, output for all commodities increased, although their rates differed. Growth rates for all agricultural commodities were substantially below the estimated growth rate for the nonagricultural sector. Highest rates of growth were for beef and fruits and vegetables with a 60% increase forecast over 15 years. Lowest growth rates were for oilseeds (7%) and wheat (21%). These patterns are observed because of two main reasons:

1. The resources available to agriculture over the 15 year period change. Capital in agriculture more than doubled (a 110% increase) while labour declined 8% and the use of fertilizer also increased 62% during the 15 year period.
2. There are technological changes that take place and these are captured firstly in the intercept term and secondly by some of the time varying parameters of the production function.

Since the results reported are generated not only from the supply component of the FAP model but also from their demand structure it is noted that consumption of beef in Canada was forecast to rise about in line with supply. Dairy consumption rose only 10%, requiring a substantial increase in exports by 1985 (24% of production). Exports of poultry, pork and fish remained stable at one third of production. For

Table 3.1: Commodity Production in Canada under Base Forecast, High Prices and Low Prices

	Base Case	High Prices	Low Prices
WHEAT (m.t.)			
1975	17,308	17,308	17,308
1976	17,600	18,392	16,624
1977	17,746	19,291	16,455
1978	17,872	19,493	16,551
1979	17,982	19,658	6,637
1980	18,079	19,801	16,711
1985	18,401	20,302	16,952
COARSE GRAINS (m.t.)			
1975	20,450	20,450	20,450
1976	21,075	22,104	19,826
1977	21,686	22,947	20,310
1978	22,273	23,801	20,768
1979	22,840	24,626	21,209
1980	23,390	25,421	21,638
1985	25,926	29,042	23,636
BEEF (m.t.)			
1976	1,118	1,118	1,118
1976	1,148	858	1,212
1977	1,179	903	1,241
1978	1,210	932	1,270
1979	1,241	961	1,298
1980	1,273	992	1,328
1985	1,440	1,146	1,485
DAIRY (m.t.)			
1975	8,566	8,566	8,566
1976	8,793	6,570	9,286
1977	9,029	6,913	9,503
1978	9,267	7,135	9,724
1985	11,027	8,778	11,376
POULTRY & PORK (m.t.)			
1975	276	276	276
1976	283	273	287
1977	289	280	292
1978	294	288	297
1985	325	328	323
OILSEEDS (m.t.)			
1975	548	548	548
1976	570	551	578
1977	592	579	597
1978	614	608	615
1985	761	800	741

fruits and vegetables (including plantation crops) there was a substantial reduction in dependence on imports (from 26% to 3%). Wheat and coarse grain exports rose modestly from 14.9 mt to 18.8 mt.

In Table 3.2 a comparison of historical and "model" simulation results with observed wheat production shows that the model does not incorporate the highly variable effects of weather. Aside from these shocks model results compare reasonably well with past output levels and with expected future production levels. Similar comparisons for other commodity groups may also be made.

Table 3.2: A comparison of actual versus estimated wheat production for Canada (in million tonnes)

Year	Actual Production	Canadian[a] Forecasts	FAP Model Results
1975	17.1		18.7
1976	23.6		18.6
1977	19.8		19.1
1978	21.1		20.0
1979	17.5		19.8
1980	19.1	18.8	19.5
1981	24.8	19.4	19.7
1982	27.6	20.0	19.9
1983		20.6	20.3
.			
.			
.			
1989			21.4

[a]Official forecast by the Ministry of State for Economic Development. Unpublished Federal Government Forecasts, 1979.

Grains Market Scenarios

Numerous simulation runs were made to test the sensitivity of the model. Two such changes are presented here. First, under a strong world grains market scenario, the wheat and feedgrain prices were doubled for the 1975-85 period. Second, under a weak world grain market scenario, the wheat and feed grain prices were reduced 50% for the 1975-85 period. All other commodity prices remained at 1975 levels. It should be noted that in the allocation model relative prices are important and that price changes of this magnitude are fairly severe. A summary of changes in the production levels of the major commodity groups for selected years is given in Table 3.1.

Both wheat and feedgrains production was forecast to increase about 10% (above the base forecast) under the high price regime and decrease about 8% for the low price scenario. These results with an elasticity of 0.1 are low compared with other Canadian studies which show wheat supply elasticities of 0.5 to 1.5 (Coleman, 1979). However, large price changes were assumed and both wheat and feedgrain prices were increased so that supply elasticities would be expected to be lower than for a situation where a price change ceterus paribus is made.

Beef and dairy responses show a large immediate production decline under high grain prices, about 20-25%. Under low grain prices production increased about 5%. Beef production is expected to increase, initially, under high grain prices as farmers sell breeding stock. Production would eventually decline as fewer offspring were available for slaughter from the reduced breeding herd.

The dairy sector is highly controlled in Canada with prices set by cost-of-production formulae, and output restricted through quotas. Milk production is unlikely to be very strongly affected by grain prices. Higher grain prices would affect milk prices, which would reduce demand and hence output. These changes, however, would likely be considerably smaller than those forecast by the model.

Poultry and pork production in the model were quite unresponsive to feed prices. The poultry sector in Canada, like the dairy sector, is highly regulated. There is a response to feed prices through cost of production formulae. Holliday (1979) noted that adjustments by the poultry sector to higher feed costs occur in Canada but the response lags are longer than in the U.S. The pork sector is uncontrolled and responds to higher grain prices, particularly in Western Canada. In spite of these two sectors being aggregated in the model (with fish which is unresponsive to feed price changes) a somewhat larger effect would be anticipated than these results

Oilseed production was only slightly affected by higher grain prices. An increase in grain production would sharply reduce oilseed production since the largest area for grain production is the Prairies and there is limited opportunity for net increases in total acreage. This earlier version of the basic linked model does not treat cultivated land as a limiting resource and consequently the response noted for oilseeds.

This review is fairly brief. The reader may refer to the earlier reports for more details. In general, these tests were encouraging -- although certain problems were detected in aggregate supply responses over the 15 year period, they appeared to correspond to those made by "in house" researchers in Agriculture Canada. The sensitivity to price changes was noted, and the structure of the model, based upon the concept of an allocation of limited resources between alternatives, appeared sound. At research meetings with those involved it was decided that a revised allocation model would be specified and estimated.

Since reporting these simulation results several changes to the basic model have been made. Improvements continue and the work is still ongoing.

3.1.3 Proposed Changes to the Canadian Basic Allocation Model

To overcome some of the problems described above several required changes to the structure of the simplified model are noted. These changes have been incorporated into a revised allocation model reported on in the next section.

1. The land constraint

   It was noted earlier that three resources (capital, labour and fertilizer) constrain production. The importance of arable land and improved land of other categories in the production of both marketable crops and roughage requires that land be treated explicitly as a limiting resource. The significance of fertilizer as a limiting resource is questionable.

2. The aggregation of livestock

In the basic model beef and dairy are aggregated. In Europe where the beef and dairy herd are generally a single herd, this may be appropriate. In the Canadian situation it is not appropriate because of the very different structure of these sectors. Our analyses with the model indicated that for beef price changes, the production response was positive and immediate. In practice, the immediate response by beef producers to a price change is with respect to breeding stock numbers (cow herd size). Once the size of the herd is determined, then beef output is to a large degree predetermined. By treating herd size as the decision variable in the allocation model and relating beef output to these numbers, a fairly simple dynamic adjustment process may be incorporated. Historically, beef herd size and slaughterings have been cyclical in response to price. The dairy herd on the other hand has decreased continuously over time. The nature of the demand and the changes in technology with improving milk yields per cow have influenced this trend. Both the dairy and poultry industries in Canada operate under supply management with any growth in the output being related to domestic demand and export prospects and to the level at which certain policy variables are set (e.g. target prices, trade quotas). Pork production on the other hand is fairly responsive to domestic price changes and tends to follow those of Canada's main trading partner - the U.S. These structural differences require that pork and poultry outputs be two separate activities in the allocation model and that the production from the dairy and beef herds also be treated independently.

3. Feedgrain consumption

As will be elaborated later, grain consumption per animal unit in the basic allocation model is derived using scientific requirements for pig and poultry production and the remainder of feed disappearance is allocated to beef and dairy. This procedure appears to allocate too much of the grain used for feed consumption to beef and dairy and an insufficient amount to pork and poultry. In Table 3.3, a comparison between Agriculture Canada's estimates and those used in the model is provided.

Table 3.3 Grain Consumption by Livestock Category - 1971

Commodity	Basic Model	Agriculture Canada[a]
	(1000 mt.)	
All bovine and ovine	13.9	7.5
Other animals (pork and poultry)	5.2	12.2
Total	19.1	19.7

[a]Source: Candler, et al. 1974

There is a need to reconsider the feed allocation scheme and devise a method of allocating feed disappearance between four classes of animals. In the case of Canada it was noted that the supply utilization accounts sometimes allocated unexplained balance residuals to feed utilization. An extremely important source of feed is forage and this should be considered if a complete feed allocation procedure is to be devised.

4. The production function

The output level of commodity i is related to the total endowments in the agricultural sector and to the commodity-specific levels to which these endowments are allocated. It is noted that $\delta_{it} + \varepsilon_{it} + \rho_{it} = 1$ implying that output of agriculture as a whole is homogeneous of degree 1; if all inputs are doubled output will also double. For an individual commodity the requirement is that $\gamma_i + \beta_i + \eta_i < 1$. This indicates that the relationship is homogeneous of degree $\gamma_i + \beta_i + \eta_i$, and since the sum of these exponents is less than one decreasing returns to scale hold true. If the sum of these coefficients is fairly small then fairly large variations in the commodity-specific factor inputs levels will result in relatively minor changes in output responses. It was our experience that these coefficients, in general, appeared to be low, although this was not the case for all commodities. Further testing and evaluation of these coefficients is on-going and various alternative specifications are being tried. It is argued by Frohberg (1980) that the fundamental requirement of the allocation model is that the supply responses (elasticity of supply with respect to price) be acceptable. For a given period, where total agricultural labour and capital are fixed any supply response must depend on the sum of the values of γ_i, β_i and η_i. Over the longer run the intercept term α_i is time dependent and hence supply elasticities also depend on α_i. Various tests have resulted in long-run supply responses somewhat greater than conventional econometric procedures tend to portray. However, these responses provided by the allocation model are true long-run responses in that total agricultural capital and the labour force are allowed to adjust to price changes. Using the allocation procedure cross-price elasticities may also be calculated. It is our opinion that more appropriate supply responses would be obtained if empirical results for the individual commodities resulted in returns to scale closer to 1. For the industry as a whole, this condition is met by restrictions placed on the coefficients during estimation. It would also be advantageous if the nonlinear algorithm used had the flexibility to allow for different model or production function specifications. The advantage of this special algorithm is that being problem-specific it may be more efficient than a general algorithm. For the alternative allocation model, detailed in the next section, a considerable amount of work was required to develop an algorithm to accommodate the model specified.

In summary, the Canadian basic linked model appeared to perform reasonably well for the 15 year forecasts. Aside from the problems noted, the supply module produced results that compared very favourably with forecasts utilizing other methodologies. It did not track the livestock cycles well, since there was no provision for delayed responses in herd sizes. The inclusion of country-specific policy variables or constraints could enhance the model's results. It is also believed that the development and management of the basic linked models for the existing 20 countries could have substantial short-term payoffs, provided some of the problems mentioned could be overcome. It was decided that an attempt would be made to respecify the structure of the Canadian model and continue to use the same basic methodology. Some of the changes noted may be useful in respecifying the basic model for other countries.

3.2 A Revised Allocation Model

In attempting to develop a revised Canadian allocation model we have relied upon the experience of Fischer and Frohberg and also upon others working closely on an agricultural sector model of the European Community (Frohberg et al., 1978). The structure of the allocation model detailed approximates that for the European Community.

Agricultural capital, labour and land are treated as limiting resources. It is assumed that the profitability of the agricultural sector relative to that of the nonagricultural sector will determine the absolute level of these resources in period t. Over time aggregate levels change as investment in the sector takes place or as labour moves into or out of the agricultural labour force. These resources are to be allocated between alternatives within the agricultural sector.

The allocation model is based upon profit maximization over the long run; that is, farmers maximize expected gross revenue minus variable costs. This model, for a single period t, may be specified as:

$$\max_{K_i, L_i} Z = \sum_{i=1}^{7} (P_i^e Y_i^e - C_i) A_i + \sum_{i=7}^{11} (P_i^e Y_i^e - C_i)\, A_i - \sum_{i=7}^{11} a_{1i} (A_{it} - A_{it-1})^2$$

subject to:

$$\sum_{i=1}^{7} A_i - TA \le 0 \qquad \sum_{i=1}^{11} L_i - TL \le 0$$

$$\sum_{i=1}^{11} K_i - TK \le 0 \qquad a_2 * A_{11} - A_7 \le 0$$

and with

$$A_i = \nu_i * (TK)^{\varepsilon_i} * (TL)^{\delta_i} * (\frac{K_i}{TK})^{\beta_i} * (\frac{L_i}{TL})^{\gamma_i}$$

where

$$\varepsilon_i + \delta_i = 1 \text{ and } \gamma_i + \beta_i < 1$$

The subscripts for the commodities are given as

i = 1, wheat (hectares)

= 2, coarse grains (hectares)

= 3, oilseeds (hectares)

= 4, vegetables (hectares)

= 5, fruit (hectares)

= 6, industrial crops (hectares)

= 7, roughage (hectares)

= 8, pork (mt. pork)

= 9, poultry (mt. protein eq.)

=10, dairy (cow numbers)

=11, beef (herd size)

The variables and parameters are defined as:

P_i^e = the expected price of commodity i

Y_i^e = the expected yield/unit (hectare or animal unit) for commodity i

A_i = the number of units (hectares, mt. or animal units) of commodity i

TA = the total area of improved land less summerfallow area

K_i = the capital allocated to commodity i (in $)

TK = the total capital stock in agriculture

L_i = the labour allocated to commodity i (person years)

TL = the total agricultural labour force (person years)

C_i = variable costs for commodity i, included are purchased feeds, fertilizers, chemicals, energy costs, machinery repair costs, building repair costs and other items.

a_{1i} = a penalty in the objective function that can, if used, prevent substantial changes between livestock output levels (A_i) for successive years

a_2 = a coefficient (animal units per acre) that relates to the carrying capacity of improved pastures to the number of grazing animal units

As indicated earlier it may also be convenient to rewrite the relationship between A_i and factor inputs as:

$$A_i = \alpha_i {*} K_i^{\beta_i} {*} L_i^{\gamma_i}$$

where

$$\alpha_i = \nu_i {*} TK^{\varepsilon_i - \beta_i} {*} TL_i^{\partial_i - \gamma_i}$$

or given that

$$\varepsilon_i + \partial_i = 1$$

$$\alpha_i = \nu_i {*} TK^{\varepsilon_i - \beta_i} {*} TL^{1 - \varepsilon_i - \gamma_i}$$

A time subscript is required for the time varying nature of parameters of the production function and for some of the other relationships. We have omitted this in order to simplify our presentation. In interpreting the above equations, the criterion function specifies that expected gross revenue less costs is maximized for both crop activities and livestock activities. A penalty term to the function prevents excessive changes in livestock output from period to period. In all cases, allocation decisions must fall within resource constraints. One additional constraint relates roughage requirements to the size of the beef herd only. Essentially it is an attempt to recognize that the summer grazing *per se* is not a limiting resource as this requirement for both the dairy and beef herds is met through pasturing not explicitly considered in the model. Spring grazing and winter feed are limiting resources. These requirements are mainly met by tame hay acreage. If winter feeding requirements are to be increased, then this expansion is at the expense of land used mainly for wheat, coarse grains or oilseeds as specified in the structure of this model. It is noted that approximately 10.5 million hectares of land are summerfallowed each year and this fallow land is also summer grazed. There are different approaches to tackling roughage requirements but essentially this specification results in only small modifications to an existing algorithm.

The conceptual model allocates scarce resources to production alternatives. In particular, total agricultural capital and the labour force are important driving forces. The functional relationships explaining the level of these variables are given below. Also, we report on our method of attempting to allocate variable input costs among the different commodities so that the criterion function of the model may be specified. The approach adopted would be particularly useful if a disaggregation of the input-output table of the agricultural industry of Canada is attempted. A revised feed allocation procedure is detailed.

3.2.1 Resource Capacities

In order to estimate capital stock, the labour force and the amount of arable land in agriculture over the forecast period, a fairly simple relationship between these resource capacities and a number of independent variables is specified. The functional forms and the selected variables are those specified by Fischer & Frohberg (1980). These appeared to perform in a satisfactory manner in our earlier evaluations. Some of the data series were revised because of discrepancies encountered.

Capital Stocks

Investment is an important component of a model of this nature. It is important because labor and capital stocks are the critical inputs into the production process; investment is also a significant component of aggregate demand. By definition investment represents spending devoted to increasing or maintaining the stock of capital; gross investments represent total additions to the capital stock, net investment is the change in this capital stock after allowing for depreciation (see Tables 3.4 and 3.5) Investment is assumed to be equal to savings. Agricultural investment as a share of this total investment (I^A/I^T) is mainly determined by the profitability of agriculture relative to that of the nonagricultural sector. Two measures of this relative profitability are used - the ratio of gross domestic product for agriculture to that of the nonagricultural sector and a ratio of prices. The various functional forms used are presented as:

Table 3.4. Capital Stock and Gross Capital Formation by Sector

	Capital Stock						
	Agriculture	Non-Ag. Sector	Total	Gross Ag. Investment	Gross Capital Formation	$\frac{I^A}{I^T}$	$\frac{P^A}{P^{NA}}$
			(m. $ constant)				
1961	5,806	113,167	118,913	788			
1962	5,935	117,936	123,871	893	11,207	.080	1.117
1963	6,095	123,032	129,127	998	11,847	.084	1.33
1964	6,356	129,566	135,922	1,095	13,458	.081	1.34
1965	6,383	137,407	143,190	1,150	15,141	.075	1.30
1966	6,853	145,896	152,749	1,144	17,161	.066	1.33
1967	7,332	153,782	161,114	1,199	17,096	.070	1.17
1968	7,815	161,335	169,150	1,089	17,122	.063	1.08
1969	7,758	170,037	177,795	999	17,970	.055	1.00
1970	1,585	178,561	186,146	821	18,016	.045	1.04
1971	7,298	188,339	195,637	883	19,440	.045	1.00
1972	7,424	198,459	205,883	1,102	20,613	.053	0.96
1973	7,822	210,337	218,159	1,312	22,362	.058	1.10
1974	8,465	222,575	231,040	1,376	23,976	.057	1.56
1975	9,603	234,583	244,186	1,650	25,423	.065	1.34
1976	10,533	246,657	257,190	1,750	25,979	.067	1.32

Statistical Review, Stats. Canada, Cat. 3-1501-501

Table 3.5. Agricultural Capital Stocks

	Building	Machinery	Total	Gross Capital Formation Price Deflator	Total
	-------(m. $ current)----------			-----(m. $ constant)-----	
1961	1,581	2,565	4,146	71.4	5,806
1962	1,637	2,660	4,297	72.4	5,935
1963	1,725	2,810	4,535	14.4	6,095
1964	1,879	3,015	4,894	77.0	6,356
1965	2,076	3,263	5,339	81.1	6,383
1966	2,297	3,549	5,846	85.3	6,853
1967	2,663	3,723	6,386	87.1	6,383
1968	2,982	3,872	6,854	87.7	7,815
1969	3,166	3,925	7,019	91.4	7,758
1970	3,306	3,923	7,229	95.3	7,585
1971	3,393	3,905	7,298	100.0	7,298
1972	3,641	4,125	7,766	104.6	7,424
1973	4,352	4,518	8,870	113.4	7,822
1974	5,571	5,705	11,276	133.2	8,465
1975	6,908	7,516	14,424	150.2	9,603
1976	8,077	9,027	17,104	163.9	10,435

Source: Unpublished Statistics Canada data.

$$\frac{I_t^A}{I_t^T} = \left[\alpha_{I1} \Bigg/ \left(1.0 + e^{-\alpha_{I2} * t} \right) \right] * \left(\frac{GDP_{t-1}^{A,CO}}{GDP_{t-1}^{NA,CO}} \right)^{\alpha_{I3}}$$

$$\frac{I_t^A}{I_t^T} = \alpha_{I1} * \left(\frac{P_{t-1}^{A}}{P_{t-1}^{NA}} \right)^{\alpha_{I2}} * \left(\frac{GDP_{t-1}^{A,CO}}{GDP_{t-1}^{NA,CO}} \right)^{\alpha_{I3}}$$

$$\frac{I_t^A}{I_t^T} = \left[\alpha_{I1} \Bigg/ \left(1.0 + e^{-\alpha_{I2} * t} \right) \right] * \left(\frac{GDP_{t-1}^{A}}{GDP_{t-1}^{NA}} \right)^{\alpha_{I3}}$$

$$\frac{I_t^A}{I_t^T} = \left[\alpha_{I1} \Bigg/ * \left(1.0 + e^{-\alpha_{I2} * t} \right) \right] * \left(\frac{P_{t-1}^{A}}{P_{t-1}^{NA}} \right)^{\alpha_{I3}}$$

$$\frac{I_t^A}{I_t^T} = \left[\alpha_{I1} * \left(1.0 + e^{-\alpha_{I2} * t} \right) \right] * \left(\frac{GDP_{t-1}^{A}}{GDP_{t-1}^{NA}} \right)^{\alpha_{I3}}$$

$$\frac{I_t^A}{I_t^T} = \alpha_{I1} * \left(1 + e^{-\alpha_{I2} * t} \right) * \left(\frac{P^{A}}{P^{NA}} \right)^{\alpha_{I3}}$$

where

I_T^A = gross investment in agriculture in year t (in million national currency at prices of 1970)

$\tilde{I}_t^T$ = total gross investment in year t (in million national currency at prices of 1970)

GDP_t^A = gross domestic product of agriculture in year t (in million national currency at current prices)

$GDP_t^{A,CO}$ = gross domestic product of agriculture in year t (in million national currency) at constant prices

GDP_t^{NA} = gross domestic product of nonagriculture in year t (in million national currency) at constant prices

$GDP_t^{NA,CO}$ = gross domestic product of nonagriculture in year t (in million national currency) at constant prices

P_t^a = price index of agricultural commodities in year t

P_t^{NA} = price index of the nonagricultural commodity in year t

t = time variable (t = year minus 1960)

α_{Li} = parameters estimated from time series

Empirical results for the investment share are presented in Table 3.6. The second equation is selected as being the most suitable. For this equation the agricultural investment share is determined by the ratio of agricultural to nonagricultural price indices of the previous year and by last year's output ratio for the two sectors. A 1 percent improvement in agricultural prices relative to those of nonagriculture will lead to a 0.63 percent increase in the investment share; for a 1 percent increase in the gross domestic product of agriculture relative to that of nonagriculture a 0.72 percent increase results.

Table 3.6 Empirical Results for Investment Functions

Eq. No.	α_{I1}	$\varepsilon^{\alpha I2t}$	$\frac{GDP^A}{GDP^{NA}}$	$\frac{P^A}{P^{NA}}$	R^2	D.W.
1	0.026 (1.48)	2.0 (BND)	1.25 (7.86)		0.98	0.44
2	0.428 (1.58)		0.634* (3.22)	0.724 (3.28)	0.98	1.42
3	0.984 (2.40)	0.0 (BND)	0.674 (4.98)		0.98	1.35
4	0 (BND)	0.054 (1.51)		0.697 (2.47)	0.97	0.62
5	0.213 (1.89)	0.011 (0.45)	0.610 (3.13)		0.98	1.27
6	.048 (11.08)	0.254 (2.4)	0.597 (3.1)		0.99	1.66

* measured at constant prices - t-statistic in parenthesis

The capital stock in both the agricultural and nonagricultural sectors may be calculated from the investment share equation. The formula being

Capital $Stock_t$ = (Capital $Stock_{t-1}$ * (1-depreciation rate) + $Investment_t$).

The real depreciate rate currently used for agriculture is 3.8% per annum and that for the nonagricultural sector is 4.05%. The rate does not change over the period for which forecasts are made.

The Labour Force

As an input into the production process, labour is also important. We consider this resource in aggregate, and only specify its size without explicitly accounting for its quality. For agriculture, a declining labour force is generally observed while that of the non- agricultural sector has continued to grow. Over the 1951-78 period the number of workers in agriculture decreased by approximately 50 percent, from 940 thousand (18 percent of the total Canadian labour force) to 473 thousand (5 percent of the total labour force).

The agricultural labour force is measured as the number of persons employed in this sector on a full-time basis. Included are owner operator labourers, unpaid family labour and hired labour on a full-time or seasonal basis. We hypothesize that the size of this labour force depends on relative earnings in the agricultural sector versus that of the nonagricultural sector (see Table 3.7). The majority of this working force represents skilled agricultural workers and it is argued that over the long run it is the size of this skilled force that determines output. Seasonal labour needs are not considered to be a limiting factor over the longer run; through capital substitution or through improved skills any critical seasonal shortages will be eliminated. Lopez (1980), Jones (1978), and Tyrchniewicz and Schuh (1969) have reported in greater detail on this labour sector.

Several different functional forms for labour are estimated and results are presented in Table 3.7. In concept, these relationships describe the size of the agricultural labour force in the current year as an adjustment from the previous year and in response to the parity earnings between agriculture and nonagriculture. The second equation is chosen as being most suitable. The coefficient α_{L2} may be interpreted as the percentage change in the labour force due to a percentage change in the ratio of the earnings per worker in these two sectors. Labour force variables used are presented in Table 3.7.

Table 3.7 Labour Force and Relative Earnings for Agricultural and Nonagricultural Sectors

	Total Labour Force	Agricultural Labour Force	$\frac{GDPA}{GDPNA}$	$\frac{ZA}{ZNA}$
	(000)	(000)	($ constant)	
1961	6,819	681		
1962	6,690	660	0.047	0.43
1963	7,103	649	0.066	0.63
1964	7,251	630	0.070	0.69
1965	7,384	594	0.058	0.61
1966	7,640	544	0.062	0.70
1967	7,894	559	0.055	0.72
1968	8,129	546	0.041	0.54
1969	8,361	535	0.039	0.54
1970	8,597	511	0.039	0.57
1971	8,779	510	0.035	0.55
1972	8,962	481	0.034	0.56
1973	9,144	467	0.035	0.63
1974	9,326	473	0.048	0.89
1975	9,509	479	0.047	0.78
1976	9,691	474	0.043	0.80

Source: The Labour Force, Cat. No. 71-001, Statistics Canada

The various functional forms estimated are presented as:

$$L_t^A = \alpha_{L1} * \left[\frac{GDP_{t-1}^A}{GDP_{t-1}^{NA}}\right]^{\alpha_{L2}} * L_t^T$$

$$L_t^A = \alpha_{L1} * \left[1 + \exp * \left[\alpha_{L2} * \left[\frac{Z_{t-1}^A}{Z_{t-1}^{NA}}\right]\right]\right] * L_t^T$$

$$L_t^A = \alpha_{L1} * \left[\frac{Z_{t-1}^A}{Z_{t-1}^{NA}}\right]^{\alpha_{L2}} * L_{t-1}^A$$

$$L_t^A = \left[1 - \frac{\alpha_{L1}}{1 + \exp(-\alpha_{L2} * t)}\right] * L_t^T$$

$$L_t^A = \alpha_{L1} * \left[\frac{GDP_{t-1}^A}{GDP_{t-1}^{NA}}\right]^{\alpha_{L2}} * L_{t-1}^A$$

GD_t^A = gross domestic product of agriculture in year t (in million national currency at current prices)

GDP_t^{NA} = gross domestic product of nonagriculture in year t (in million national currency at current prices)

L_t^A = agricultural labour force in year t (in 1000 persons)

L_t^T = total labour force in year t (in 1000 persons)

Z_t^A = income per agricultural labourer in year t

A_t^{NA} = income per nonagricultural labourer in year t

t = time (t = year minus 1960)

Equation 2 is chosen as being most suitable. The agricultural labour force in period t is determined principally by the relative income per worker in the farm sector versus that of the nonfarm sector. The coefficient 0.057 indicates that a 1 percent change in this ratio will result in a 0.057 percent change in the labour force.

Table 3.8. Empirical Results for Agricultural Labour Force Functions

	Variable						
Equation	L_t^T	L_{t-1}^A	$\frac{GDP_{t-1}^A}{GDP_{t-1}^{NA}}$	$\frac{Z_{t-1}^A}{Z_{t-1}^{NA}}$	t	$\bar{R}^2$	D.W.
1	0.53 (1.73)		0.69 (3.71)			0.97	0.57
2		1.00 (48.0)		.057 (1.33)		0.99	2.04
3		0.97 (125.9)	0			0.99	2.06
4	0.047 (0.04)			1.91 (0.01)		0.96	0.09
5	0.94 (312.6)				1.44 (8.27)	0.96	0.48

To obtain estimates of total labour for the *ex ante* model, simulation regression coefficients relating labour participation rate to total popultion are used. The coefficient of 0.4007 indicates a participation rate of approximately 40%. Currently, this rate does not vary with time, although it may be appropriate to test whether this assumption is appropriate. The data pertaining to this estimate are presented in Table 3.9. They are derived from studies provided by the International Labour Organization.

Table 3.9 Total Observed and Estimated Population and Labour Participation Rates

Year	Total Population (000)	Labour Participation Rate (%)
1950	13,737	38.21
1955	15,736	37.43
1960	17,909	37.26
1965	19,644	37.59
1970	21,406	40.16
1975	22,801	41.84
1980	24,576	42.88
1985	26,510	42.98
1990	28,356	42.51
1995	29,999	42.92
2000	30,328	43.76

For model simulation 5-year intervals over the period 1965 to 2000 were used. An annual population growth rate for the period of approximately 1 percent was obtained from ILO. The proportion in the agricultural sector is thus derived.

Arable Land

The agricultural land base is categorized into two main types - arable land and unimproved land. The arable land base is explicitly treated in the model by allocating it to one of the eight uses -- the seven alternatives specified or to summerfallow. Unimproved land, used mainly for pasturing, is not explicitly dealt with. Through investments in land improvement practices the amount of arable land has increased slightly over the historical period (less than 1% per annum). For simulations a simple relationship specifying summer fallow acreage and arable acreage is used to determine the level of this constraint for the allocation model. Details of these specifications are presented later.

In specifying these capital, labour and land input functions, fairly straightfoward and perhaps simplistic relationships have been chosen. Since this input sector is critical to the determination of agricultural output, alternative specifications may in the future be attempted as resources permit. It may be desirable to attempt to disaggregate these inputs but in doing so a restructured allocation model would also be required. We have been hesitant to do so because of the difficulties involved in developing a new algorithm suitable for the restructured problem. Because of the iterative procedures involved in the estimation of the production function parameters a linking of several software packages is necessary. To introduce these changes would require a considerable amount of time and a familiarity with the different routines. These considerations have influenced the model specified and consequently the direction of the work. The difficulties involved in an alternative specification should not be underestimated. Having detailed the manner in which the right hand side variables of the model are estimated we now turn to the question of attempting to estimate variable costs for each of the activities over the historical period.

variables of the model are estimated we now turn to the question of attempting to estimate variable costs for each of the activities over the historical period.

The Objective Function

The objective function of the allocation model maximizes expected total revenue less costs. The objective function for a single period is defined as:

$$(P_i^e Y_i^e - C_i)A_i$$

where $(P_i^e \; Y_i^e)$ is the expected revenue per unit of activity, C_i is a set of input costs associated with production alternative $i(i=1...11)$, and A_i is the level of the activity. This statement of the objective function requires that some measure of expected returns and costs be specified, over the historical period 1961-76, and over the forecast period, for each of the 11 commodity groups. Input costs cannot be neglected since it is the expected relative profitability of each alternative that determines output in the allocation model.

There are difficulties involved in attempting to derive these coefficients for the objective function. Firstly, commodity prices and input costs must be aggregate so as to conform to each aggregate commodity group. Secondly, one must generate objective function coefficients for the time series involved, both historically and into the forecast period.

Since expected prices or expected profits determine allocation decisions various price expectation models may be considered (Box and Jenkins, 1970, Nerlove, 1971, Kantor, 1979). It is not clear which approach is appropriate. Fischer and Frohberg (1980) adopted a naive expectations model where expected prices this year are equal to last year's prices. The results reported in this study adopt a similar approach, although the Box-Jenkins methodology (1970) was also tried (see Appendix C). Farmers respond to expected revenues and there are expected price and expected yield components thereof. It is recognized that an accurate specification of these components merits further study.

In the allocation model the value of by-products derived from the primary agricultural product are added to the primary product to obtain the price per unit. Items falling into byproduct categories include fats, meat and fish meal, skins, wool and hair, etc. It is argued by Fischer and Frohberg that byproducts represent a significant component of the price to which farmers react. Since byproduct values appear relatively small in Canada, it was also decided that byproduct values would not be added to the price.

As noted by the objective function farmers are assumed to maximize expected profits. Estimates of variable input costs per unit of activity are difficult to obtain. In the BLS allocation model, capital, labour and fertilizer are treated as fixed resources to be allocated between alternatives. As such, their costs may be ignored. Feed costs are subtracted for livestock products but other variable costs for other products are ignored. The procedure adopted in this study explicitly attempts to recognize variable input costs. The difficulties encountered in the approach are noted.

Input Costs

Input costs per unit of activity are derived for two reasons. Firstly, relative costs affect allocation decisions. Secondly, inputs from the nonagricultural sector used in the agricultural sector (inter--industry flows) must be accounted for since the framework of the model is general equilibrium in nature. In attempting to meet this requirement the principal difficulty encountered is that of having enough information to be able to allocate purchased inputs between the alternatives produced on a farm. This cost allocation remains a problem even at the level of aggregation required for the allocation model. Canadian census statistics do not allocate costs between commodities and information on total variable costs per farm is not helpful since it is also necessary to know input levels per unit of activity. We have attempted to make an allocation of variable costs and describe the methodology adopted.

One possible allocation procedure relies on farm budget data prepared by specialists for particular farming systems. These budget data are available from many different sources. Federal and provincial farm management specialists prepare consensus budgets on an ongoing basis for various commodities and for various producing areas. Cost of production surveys both national and regional have been undertaken. Information on costs is collected to estimate support levels under the Agricultural Stabilization Act. CANFARM records could represent another source. These budget data are generally not available on an annual basis, nor are they available for all of the 11 commodities defined in the allocation model. As well, the procedure used and input items accounted for differ by source. It is also anticipated that if an attempt were made to extrapolate these budget data to a national account level, inconsistencies would occur. In general, it is expected that budget data will specify higher input levels than are found in practice for an average farm. It is hypothesized that these data typically represent an above average farming situation. Some evidence to support this view is presented by our analysis of tax filer data that follows.

The approach to allocating costs adopted in this study is to rely on a 1974 sample of tax filer data (150,000 farmers) and together with information from the 1974 input-output table attempt to provide a consistent allocation of costs between commodities. The sample of tax filler data collected by Revenue Canada was stratified by source, level of income, area of residence and tax status. The following major input cost items have been summed to represent total variable or operating costs per unit of activity: feed, fertilizer, chemicals, gas, oil and energy, machinery operating expenses, building operating expenses and other costs.

Interindustry input-output tables for Canada, at the most detailed level, have been balanced for 191 industries, 595 commodities and 136 categories of final demand (Statistics Canada, 1979). In spite of this detail, a problem for the agricultural sector is that the sector is treated as one industry. We have attempted to disaggregate the sector by using tax filer data, thus providing a breakdown for the major agricultural commodity groups by cost item. Each cost item multiplied by the level of the sector will provide an estimate of purchased inputs for that sector and if these are all summed an estimate of total input use for all agricultural sectors is provided.

This estimate should be consistent with the "use" level reported by the "use" matrix of the agricultural sector in the input-output table. The "use" matrix of the 1974 input-output tables indicates inputs for the entire agricultural sector (including returns to resources) to be $9,099 million. A grouping of items shows commercial feed costs as $1,040 million, fertilizer costs as $118 million, chemicals cost $252 million, gas, oil and energy costs as $357 million, building costs as $195 million and machinery costs to be $680 million.

The tax filer sample covers 51,800 wheat farmers, 10,000 coarse grain farmers, 31,030 dairy farmers, 48,180 beef farmers, 2,980 poultry farmers, 12,190 hog farmers and smaller numbers in the other categories of interest. For each of these groups of farmers, a listing of their costs and returns is provided. Table 3.10 illustrates a set of these receipt and cost data and indicates the breakdown of input costs for 31,030 dairy farmers. Similar information is available for the other commodity groups of interest.

The detailed information provided on costs for wheat farmers indicated in Table 3.10 may be aggregated into 11 cost items as indicated in Table 3.11. Likewise, it is possible to aggregate costs for other commodity groups included in this tax filer sample, namely, coarse grain farmers, corn farmers, oil seed farmers and so forth. Costs for each of these groups for each of the 11 cost items are indicated in Table 3.11. A further step involves aggregating the 11 items into 7 cost items. These data then represent total costs by the item for each of the major agricultural enterprises covered in the sample (Table 3.12).

Table 3.10 Farm Income and Expense Budgets for Dairy Farmers in Canada, 1974; abstracted from tax-filer data.

	All Sizes		
	Number Reporting	Average /Farm ($)	Average/Farm Reporting ($)
Receipts			
Wheat	3,670	222	1,875
Oats	2,815	42	461
Barley	2,890	125	1,342
Flaxseed	1,340	20	462
Rapeseed	1,185	20	521
Potatoes	1,450	64	1,372
Corn	2,805	114	1,256
Other Crops	2,310	73	975
CWB Payments	1,430	82	1,769
CWB Cash Advance	55	6	3,234
Forage Crops	3,640	109	929
Cattle	29,010	3,323	3,555
Hogs	5,725	561	3,039
Poultry	1,925	80	1,294
Other Livestock	1,955	34	533
Breeding Fees	75	2	1,020
Fur Animal and Pelts	100	0	98
Eggs	1,285	48	1,164
Dairy (Inc. Subsidies)	31,020	23,414	23,418
Fruits	190	26	4,258
Vegetables	695	79	3,540
Honey and Maple Products	2,190	68	961
Wood	3,185	136	1,321
Sand and Gravel	345	10	914
Custom Work	5,595	198	1,101
Patronage Dividends	8,735	156	554
Gasoline Tax Rebates	9,615	60	195
Subsidies	6,820	467	2,124
Insurance Proceeds	3,500	102	902
Other Farm Income	9,765	224	713
TOTAL RECEIPTS	31,030	29,864	29,864

...Continued

Table 3.10 Cont.)

Expenses			
Salaries and wages: Hired Only	21,660	1,251	1,792
CPP or WPP for Employees	1,770	5	92
UIC or WC for Employees	4,700	23	152
Rent (Land, Buildings)	12,485	307	763
Interest	23,515	1,313	1,733
Taxes	29,245	536	569
Insurance Premiums	25,985	318	380
Building Fence Repairs	27,185	706	806
Machinery Gas and Oil	28,970	912	977
Machinery Expenses	27,020	1,184	1,360
Automobile Gas and Oil	20,485	258	391
Automobile Expenses	8,660	98	350
Cattle	18,640	1,706	2,840
Hogs	3,900	101	800
Poultry	3,630	47	406
Other Livestock	1,920	15	243
Fur Breeding Stock	250	3	408
Breeding Fees	10,860	101	288
Vet. Fees and Medicine	27,105	409	468
Feed and Straw	29,590	6,586	6,907
Fertilizer	15,440	778	1,564
Sprays and Chemicals	8,850	111	390
Seeds and Plants	19,045	455	742
CWB Advance Repayment	-	-	-
Containers and Twine	23,540	1,138	1,500
Custom Work	23,540	703	926
Telephone and Electricity	28,970	513	550
Accounting and Legal Fees	18,105	72	123
Improving Land	5,900	210	1,107
Other Expenses	27,110	921	1,054
Capital Cost Allowance	25,685	3,874	4,680
Eligible Capital Property	2,260	116	1,593
TOTAL EXPENSES	31,030	24,773	24,773
Off Farm Income			
Wages	8,705	842	3,000
Self Employment	875	83	2,931
Investment	14,215	481	1,050
Other Income	7,025	259	1,145
Family Allowances	19,730	538	846
Off-Farm Income	27,640	2,203	2,473
NET FARM INCOME	31,030	5,091	5,091
TOTAL NET INCOME	31,030	7,294	7,294
SAMPLE SIZE	3,161		

Table 3.11 Tax Filer Expenses by Commodity. Canada 1974

	Wheat	Coarse Grains	Corn	Oil Seeds	Fruits	Vegetables	Potatoes	Hogs	Poultry	Eggs	Dairy	Beef	Total
							(000' $)						
Bldg. & Fence	14,037	2,263	132	1,446	1,190	1,553	1,155	5,875	940	633	21,907	17,297	62,428
Machinery:													
Gas & Oil	44,393	6,580	274	5,421	2,334	3,936	2,311	9,313	1,013	1,075	28,299	33,630	138,579
Expenses	57,550	8,764	322	6,593	2,785	3,825	3,048	10,678	1,209	1,070	36,739	36,954	169,537
Auto:													
Gas & Oil	9,583	1,250	83	1,038	688	613	320	1,962	299	296	8,005	6,793	30,930
Expenses	23,258	903	102	656	465	320	139	975	187	163	3,041	3,613	33,822
Vet. & Medicine	2,590	377	109	344	23	1,100	85	1,865	2,722	314	12,691	8,239	29,359
Feeds & Straw	10,722	2,154	120	841	702	1,627	2,262	107,272	47,710	29,866	201,695	110,814	515,785
Fertilizer	18,026	6,630	739	5,090	2,966	4,946	4,382	7,874	1,250	814	24,141	19,513	96,371
Sprays & Chemicals	9,531	1,707	230	2,140	1,957	832	1,265	1,694	423	198	3,444	4,047	27,468
Twine	9,583	1,975	387	1,803	3,692	5,131	4,075	7,692	426	1,673	21,814	20,380	78,629
Tel. & Elec.	11,189	3,305	92	1,184	1,371	2,193	680	5,278	2,105	956	15,918	13,972	58,243
Other Expenses	11,759	1,945	127	1,446	4,106	3,743	1,989	5,242	1,804	4,667	28,578	17,586	83,005

Since the sample size of tax filers for each of the commodity groups is not a constant proportion of the population, and since the number of primary producers falling into each of the commodity classifications is debatable and depends on the asumptions made, a means of relating expenses for the sample of farmers to the "use" matrix of the input-output table for 1974 was devised. By comparing total expenses per item for the sample of tax filers with total expenses per item as reported in the "use" matrix of the input-output table an estimate of proportion of each expense item covered in the sample is provided (Table 3.12). For example feed purchased is reported to amount to $1,045 million in the "use" matrix, the sample of tax filers reports having spent $516 million of feed. Raising the latter by a factor of 2.025 would make the costs similar. For fertilizer expenses the factor is 1.23, for chemicals 4.42, and so forth.

Table 3.12 A comparison of total input costs by category as reported in the use matrix and by a sample of tax filer data.

	I/O Table	Tax Filers	Coverage
	(m.'$)		%
Purchase Feeds	1,045	516	49.4
Fertilizers	118	96	81.3
Chemicals	252	57	22.6
Gas, Oil and Energy Costs	359	227	63.3
Machinery Maintenance Costs	575	282	49.0
Building Maintenance Costs	167	68	40.7
Other Costs	90	83	92.2

A formula is used to make tax filer returns consistent with the input-output data: $C_i = a_i I_{ij}$

where: C_i = total costs for cost item i,

I_{ij} = input costs for item $_i$ for commodity $_j$,

a_i = a coefficient required to raise cost item $_i$ such that total expenses for tax filer data consistent with input-output data.

The result provides a disaggregation of input costs of the I/0 table by agricultural commodity (Table 3.13). The sum of all costs is consistent with that of the "use" column for the agricultural industry. The primary inputs in the I/O table at the medium level of aggregation is 100, that at the "small level" is 49 and these have been aggregated into 7 input items shown in Table 3.13.

Input costs for 1974 may be expressed as costs per unit of activity, given the commodity classifications for the allocation model and knowing the observed levels of output for that year. These are indicated in Table 3.14. Additionally, an estimate of input costs per unit of activity must also be provided over the estimation period (1961 to 1976) and over the forecast period. Based on the assumption that this input mix does not change over time, an index of input costs by category is used to estimate costs over the estimation period. Over the forecast period the non-agricultural sector is treated as a single sector and therefore relative input costs for the different items are unknown. The price of the 10th commodity (the non-agricultural sector) may be used. Alternatively, one may adopt scenario analysis to examine trends in individual cost items.

Table 3.13 The agricultural sector of the Input-Output Table disaggregated by commodity and cost item

	Wheat	Coarse Grains	Corn	Oil Seeds	Fruits	Vegetables	Potatoes	Hogs	Poultry	Eggs	Dairy	Beef	Total
							(000'$)						
Feed	21.7	4.4	.2	1.7	1.4	3.3	4.6	217.2	96.6	60.5	408.4	224.4	104.5
Fertilizer	22.1	8.2	.9	6.3	3.6	6.1	5.4	9.7	1.5	1.0	26.7	24.0	118.0
Chemicals	53.6	9.2	1.1	11.0	8.8	4.1	6.0	15.7	13.9	2.3	71.3	54.3	252.0
Oil, Gas & Elec.	103.0	17.6	.7	12.1	6.9	10.2	5.2	26.2	5.4	3.7	82.5	85.9	359.0
Mach. Ex.	184.4	23.8	1.6	4.4	14.2	17.0	14.8	39.5	3.7	5.9	125.7	124.3	575
Bldg. Ex.	34.7	5.6	.3	3.6	2.9	3.8	2.9	14.5	2.3	1.6	54.1	42.7	167.0
Other	12.7	2.1	.1	1.6	4.4	4.0	2.1	5.7	1.9	5.0	30.9	19.0	90.0

It is noted that this allocation approach had problems. For the dairy sector total variable costs exceeded total receipts over some of the 16 years. Various explanations may be considered. If tax filler sample data were available to repeat the analyses for a number of different years perhaps some discrepancies may be pinpointed. Because of the problem noted in the dairy sector an alternative approach was adopted and this is reported below. The method however, does offer an approach for disaggregation of the I/0 table for the agricultural sector and thus provides information unavailable from other sources.

The currently used disaggregation procedure compares total returns as reported by the sample of tax fillers (per commodity group) with total cash receipts for 1974 to estimate sampling ratios. These ratios are used to adjust expenses for each of the commodity groups to a level consistent with the total population. Essentially, the procedure is the same as that reported above but the sum of individual cost items is no longer consistent with the use column of the input-output table. In Table 3.15 total receipts as reported by each of the tax filer samples is compared to total cash receipts reported by Statistics Canada. The ratio of receipts reported by tax filers to that of total cash receipts provides an estimate of sample size and this is used to weight input costs.

Costs per unit of activity are presented in Table 3.16. The estimates were derived by raising total costs by commodity group by the factor indicated and then using output levels (acreages, tonnes, etc.) to derive costs on a per unit basis. A comparison of these costs (per unit) with those derived using other procedures indicates problems are still

Table 3.14 The cost matrix -- input costs per unit of activity for the allocation model.

	Wheat	Coarse Grains	Oil Seeds	Fruits	Vegetables	Pork	Poultry	Dairy	Beef
Unit	ac.	ac.	ac.	ac.	ac.	m.tons	m.tons	head	head
					($/unit)				
Feed	1.5	1.5	0.8	64.5	28.5	392.4	1453.2	198.3	29.9
Fertilizer	1.7	1.7	2.9	165.6	40.0	17.5	23.5	12.9	3.2
Chemicals	3.6	3.6	5.0	397.3	35.2	28.4	149.5	34.6	7.2
Gas, Oil & Energy	6.8	6.8	5.5	315.1	53.8	47.2	84.0	40.1	11.4
Machinery Ex.	11.7	11.7	2.0	642.8	110.9	71.3	89.2	61.0	16.6
Building Ex.	2.3	2.3	1.6	133.4	23.3	26.2	35.9	26.3	5.7
Other	1.7	1.7	0.7	201.2	21.5	10.2	64.6	15.0	2.5

Table 3.15 Total Expenses and Receipts for Tax Filer Returns by Commodity Groupings - 1974

	Wheat	Coarse Grains	Oil Seeds	Fruits	Vegetables	Pork	Poultry	Dairy	Beef
# Reporting	51,800	10,258	6,370	4,650	3,855	12,190	2,980	31,030	48,180
					(000'$)				
Expenses:									
Feed	10,722	2,154	841	702	3,889	107,272	77,576	201,695	110,814
Fertilizer	18,026	6,630	5,090	2,966	9,328	7,874	2,064	24,141	19,513
Chemicals	12,121	2,084	2,484	1,980	2,282	3,559	3,657	16,135	12,286
Gas, Oil & Energy	65,165	11,135	7,643	4,393	9,765	16,553	5,744	52,222	24,128
Machinery Ex.	91,997	11,642	7,432	6,942	16,536	19,345	4,728	61,594	42,605
Building & Fence Repairs	14,037	2,263	1,446	1,190	2,708	5,875	1,573	21,907	17,297
Other Expenses	11,759	1,945	1,446	4,106	5,736	5,242	6,471	28,578	17,586
Receipts:									
Tax Returns	985,857	118,355	107,238	72,535	148,494	314,636	167,316	926,679	942,015
Total Reported Farm Cash	1,745,000	620,000	552,000		1,226,000	778,000	741,000	1,317,000	1,681,000
Tax Return Receipts at % of Total Farm Cash Receipts	56	19	19		18	40	22	70	56
Factor	1.78	5.26	5.26		5.55	2.5	4.54	1.43	1.78

Table 3.16 Expenses per unit for allocation model - 1974

	Wheat	Coarse Grains	Oil Seeds	Vegetables, Fruits & Ind. Crops	Pork	Poultry	Dairy	Beef
Unit	($/ac.)	ac.	ac.	ac.	m.tons	m.tons prot. eq.	per cow	per beef a.u.
				($/unit)				
Feed	2.70	2.70	2.0	62.2	423.0	3192.0	139.9	22.9
Fertilizer	3.70	3.70	12.3	166.5	31.0	84.9	16.7	4.0
Chemicals	1.8	1.8	6.0	57.7	14.0	150.5	11.2	2.5
Gas, Oil & Energy	9.8	9.8	18.4	191.8	65.3	236.4	36.2	5.0
Machinery Ex.	12.6	12.6	17.9	318.1	76.3	194.5	42.7	8.8
Building & Fence Repairs	2.1	2.1	3.5	52.8	23.2	64.7	15.7	8.8
Other Expenses	1.7	1.7	3.4	83.3	20.7	266.3	19.8	3.6
TOTAL	34.4	34.4	102.2	932.4	653.5	4,189.3	281.7	50.4

evident. The procedure adopted should be viewed as an attempt to provide input costs without a major commitment of resources to additional primary data collection.

The allocation of feed costs to livestock

An important cost component in livestock production is feed costs. It is, therefore, also necessary to determine feed requirements per unit of livestock product.

Aside from this cost allocation problem it is also important to be able to determine that proportion of total grain supply or other feed stuffs required for live- stock production. This aspect is also extremely important from a trade point of view since in Canada a large proportion of coarse grain supply is fed, leaving exports as the residual. Corn and other protein feeds are imported.

Supply utilization accounts indicate total feed use for each feedstuff over the historical period but do not allocate this feed use between livestock categories. Over the forecast period a complete accounting of the supply and use of feeds is also required.

In attempting to detail feed use several different approaches are possible. One approach is based on the physiological requirements of different classes of animals. Knowing these daily requirements over the different feeding periods and over different livestock categories an estimate of total annual requirements for all livestock may be provided. It is also possible to attempt to consider the nutrient content of each feedstuff and relate these to the nutrient requirements for each animal class. An intensive research effort (Candler et al. 1974) attempted to balance requirements against supply for a breakdown of 16 different animal classes and for 13 different sources of feed.* Nutrient specifications included protein and energy content and other requirements of importance. A balance between feed supply and feed demand over one year was attempted. Estimates were also regionalized by province.

Various difficulties were encountered in this work. Generally, it was found that estimated feed requirements for an aggregate of all animals appeared to be less than total supplies. Therefore, in order to balance apparent feed disappearance with feed requirements an adjustment in the requirements was appropriate. Essentially, the approach detailed in this study follows a similar approach but requirements are not balanced on the basis of a least cost formulation procedure. Various animal categories have been specified, their requirements per feed category over a one-year period were determined, and an attempt was made to balance supplies and use.

It is also noted that tax filer data together with information from the Canadian input-output table, for 1974, provides an estimate of purchased feed use by livestock sector. The disadvantage in this

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*Animal classes - bulls, milk cows, yearling dairy heifers, beef cows, replacement heifers, fed heifers, dairy calves, beef calves, steers 1 year and over, pigs under 6 months, pigs over 6 months, broiler chickens, laying hens, other poultry, lambs, sheep.

Feedstuffs - wheat, oats, barley, rapeseed meal, corn, mixed grain, millfeeds, screenings, soybean meal, hay, corn fodder, improved pasture, unimproved pasture.

approach is that "on farm" feed use is not accounted for and it would be fairly difficult to decide on appropriate allocation rules for this "on farm" use. A starting point could assume that poultry and hog feeding often involves formula feeds purchased from mills, whereas the beef herd is generally fed grain not passing through commercial channels. The dairy herd is fed both home-grown and purchased feeds.

An alternative econometric approach involves specifying a functional relationship between feed requirements for each feedstuff category and the number of animals fed or gross output per animal category. These functional relationships have been estimated and are reported on. In this approach a disaggregation of feed use by each class of animal has not been attempted, mainly because it is not necessary. The supply utilization accounts require an estimate of total feed use and it is only for the allocation model that an allocation of feeds to different animal classes is required.

Roughage is also an important component of feed for both the dairy and beef herd. In the confrontation model developed by Candler et al (1974) an attempt was made to detail the allocation of corn fodder, hay, improved pasture and unimproved pasture. The latter three categories were regionalized. Both winter and summer feeding requirement differences were considered. A regional agricultural model (Harrington, et al. 1977) using a linear programming approach divided the grazing season into 3 periods (pasture feeding May and June, July and August, and September and October) and 3 different methods of preserving feed for winter were detailed (hay, cereal silage and straw). Various sources of feed were considered - namely improved and unimproved pasture, grass hay, perrennial hay and grass and corn silage. Capability maps for Canada based on climate and soil characteristics show vast areas falling into classes 5 and 6 - a class of use primarily suited to grazing. A study by Graham (1977) attempted to estimate the value of crown range or community pastures assuming that beef ranchers adjust their herd size to the availability of scarce early spring, summer or fall grazing. The shadow price of an animal unit month of grazing was determined using 30 different ranches as case study situations. These reports have indicated some of the difficulties associated with attempting to consider the allocation of roughage to various animal groups.

Canadian supply utilization accounts for feedstuffs do not detail the various categories of roughage. Even if they did, an allocation would be difficult. The approach adopted in this work classifies roughage into 2 classes - improved and unimproved pasture categories. The unimproved category is considered to be utilized entirely for summer grazing. Given the vast areas of summerfallow (approximately 11 million hectares) and land following into classes 5 and 6, it is assumed that summer grazing does not limit the expansion of the beef and dairy herds over the period of interest. However, improved pasture, some of which is used for early spring grazing and the majority thereof which is used for winter feed purposes (hay and silage), is a limiting factor.

In the allocation model total available land is allocated to three major uses - summerfallow, improved pastures or grains and other crops. An expansion of the herd size requires more land in improved pastures and this expansion is only possible if less land is allocated to summerfallow or to grains and other crops. Over the planning horizon as the total improved land area is increased (due to the breaking of more land) or as less land is allocated to summerfallow, a larger acreage may be allocated to other uses. The carrying capacity of improved pastures (animal units per acre) has trended upward over the historical period. The analyses allows for this trend. Given the importance of the grazing and livestock sectors to Canadian agriculture, an extension to this study may examine changes in winter feeding or winter fodder conservation practices or attempt to model this sector in more detail.

In the sections that follow,three different aspects are reported. Initially, the approach used by Fischer and Frohberg (1980) in their allocation model is briefly discussed. Secondly, we report on the procedure adopted in allocating feeds between four livestock classes. Lastly, the results for an econometric specification are also noted. The latter specification is used when the supply module is specified using econometric relationships. The former approach is used for the allocation model.

Feed Allocation for the Basic Linked Approach

Fischer and Frohberg (1980) devised rules for allocating feeds between two classes of animals, namely pork and poultry and bovine and ovine animals (mainly beef and dairy animal categories)*. Major allocated feed items included wheat, rice, coarse grains, dairy products, protein feeds and

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*Since this time further attention has been given to the feed allocation procedure. A more elaborate approach is currently used. This, of course, is also true for other components of the model since this is an ongoing research effort.

other food products (by products and waste at the farm or industry level of foods). The amount fed for each of these categories over the historical period was known. The problem involved determining how much was fed to each of the two livestock categories.

Essentially, the procedure estimated the amount of feed required to produce a ton of product for pork and poultry adopting feeding standards as specified by nutritionists. The balance of all unallocated feeds was assumed to be fed to the beef and dairy categories. It is indicated that a ton of pork requires 0.7 tons of wheat, 2.9 tons of coarse grain and 0.228 tons of protein feed converted to protein equivalents. These requirements can be substituted for by feeds from other sources, namely milk byproducts, wastes or byproducts from other sources. The substitution relationships have been detailed by the authors. The basic requirements (wheat, coarse grain and protein feeds) are assumed to be constant over time, but since the amount of byproducts produced varies from year to year, the net result is that there is some variation in these basic feed requirements over time.

Difficulties that emerged from this approach are briefly noted. Firstly, the respecified allocation model requires an allocation of feed between four different livestock classes. Secondly, the approach of allocating a residual to beef and dairy was seen to cause difficulties. Our analyses indicated that this residual was too large to be acceptable in the Canadian situation. It may also be too large for the other countries. Thirdly, the substitution rules allowing for the feeding of wastes or byproducts may be appropriate in some countries but it was considered that these sources are of minor significance in our case.

An Allocation Between Four Livestock Classes

The results presented in this section are based on data abstracted from several sources. Production and feed use data are based on the aggregation procedures reported by Sichra (1980). As a starting point, physiological feeding requirements for pork and poultry used by Fischer and Frohberg (1980) were adopted. The requirements for dairy and beef animals are coefficients from the regional linear progamming model developed by Harrington, et al. (1977). In order to acheive a satisfactory balance between estimated use and supply of feeds these coefficients were revised as detailed. A more comprehensive allocation procedure would require a major research effort and resources did not permit this.

The initial set of feeding coefficients used are presented in Table 3.17. These coefficients for pork and poultry are the amount of feed required per ton of product. Feed requirements for dairy and beef are based upon the requirements per animal unit over an entire year. For dairy it was necessary to adjust feed requirements for changes in the milk yield per cow over time. A cow yielded 2.87 metric tons of milk per year in 1961 - 3.89 tons in 1976. We assumed that roughage and the basic diet indicated in Table 3.17 would account for 3.42 tons of milk per year, above that level additional grain will be fed at a rate of 1 kg. of grain per 2.5 kg. of milk produced.

Table 3.17 Feed Requirement Coefficients per ton of Product or per Animal Unit

	Pork[1]	Poultry	Dairy[2]	Beef[3] (Herd only)	Feedlots[4] animals
	(m.tons) (pork)	(m.tons) (prot.eq.)	(A.U.)	(A.U.)	(A.U.)
Wheat (m. tons)	0.70	7.69	0.07	0.01	0.10
Coarse grains (m. tons)	2.90	17.94	0.66	0.09	o.88
Protein feeds (m.tons prot.eq.)	0.23	2.69	0.03		

1. A conversion rate of 0.098 m. tons of protein per metric ton of pork.
2. A medium grain diet for Quebec dairy farmers - 10% wheat and 90% coarse grains.
3. Wintering requirements for a beef cow in Alberta.
4. 300 lb. gain at 2.1 lb. gain per day requires 143 days of feeding with 15 lbs. grain being fed per day. Total grain intake is 0.98 m. tons overs 143 days.

Applying these feed standards resulted in feed costs for pork and poultry that were relatively low. Total feed costs for pork averaged 35 percent of total revenue over the 16 year period, for poultry they averaged 46 percent. Since coarse grains are the most important feed Table 3.18 is presented to indicate this allocation of coarse gains between animal classes. The residual of unallocated feed is high, averaging 34 percent. This approach of allocating feed to pork and poultry alone would in 1976 only allocate 2,000 tons out of an observed total of 13,687 tons that was fed. Feed costs allocated to dairy averaged 16 percent of total revenue, for the beef category they averaged 24 percent. The latter may appear high, but it represents an aggregate for both the herd and feedlot animals.

Table 3.18 An Allocation of Coarse Grains between Animal Classes

	Pork	Poultry	Dairy	Beef	Total Allocated	Total Fed	Residual	Residual
					(000' m tons)			%
1961	1333	1265	1962	2783	7343	8490	1146	14
1962	1346	1265	1927	2820	7358	10551	3193	30
1963	1340	1305	1882	2856	7386	11188	3802	34
1964	1449	1391	1861	3074	7775	10901	3127	29
1965	1376	1437	1825	3258	7897	11780	3883	33
1966	1387	1520	1755	3402	8084	13161	5077	39
1967	1633	1587	1690	3431	8341	11804	3463	29
1968	1608	1582	1640	3423	8254	12356	4102	33
1969	1533	1720	1609	3453	8315	14988	6673	45
1970	1860	1863	1561	3441	8725	15936	7210	45
1971	2127	1826	1579	3556	9088	16982	7894	46
1972	1902	1832	1678	3786	9199	14327	5130	36
1973	1858	1906	1757	4082	9602	15000	5397	36
1974	1840	1899	1839	4331	9909	14520	4611	32
1975	1569	1733	1944	4667	9913	15609	5696	36
1976	1541	1851	2011	4892	10295	13687	3392	25

Given the fairly large unallocated residual, the option chosen was to revise these coefficients. Since most budget data indicate that feeding costs for pork and poultry should be higher, these coefficients were increased by 20 per cent. After this adjustment the residual of unallocated feed for wheat was 4 percent, for coarse grains it averaged 29 percent. Since this residual was still fairly large a further adjustment to all coefficients for all livestock classes was made - a 25 percent increase in the requirements was decided upon. The coefficients for the different classes of livestock after these adjustments are presented in Table 3.19.

Table 3.19 Adjusted Feed Requirement Coefficients per Ton of Product or per Animal Unit

	Pork	Poultry	Dairy	Beef (Herd only)	Feedlot animals
	(m.tons) (pork)	(m.tons) (prot.eq.)	(A.U.)	(A.U.)	(A.U.)
Wheat (m.tons)	0.84	9.23	0.07	0.01	0.10
Coarse grains (m. tons)	4.35	26.91	0.83	0.12	1.10
Protein feeds (m. tons prot. eq.)	0.29	3.49	0.03		

Results after these adjustments placed total feed costs for pork at 50 percent of total revenue, with a range from 36 percent for 1969 to 69 percent for 1974. For poultry, the average was 60 percent, excluding 1973 and 1974 when high feed costs resulted in costs of 98 percent and 81 percent respectively. Dairy feed costs represented 18.5 percent of total revenue and for beef it was 29 percent. Table 3.20 is prepared to indicate the allocation between livestock classes after these revised coefficients are used. The residual averages 7.4 percent (1969 to 1971 excluded). During these years producers were feeding at a higher rate because of poor market conditions (the LIFT program years).

The coefficients presented in Table 3.19 are used in our analysis, even though further adjustments may be appropriate. Given the fairly arbitrary adjustment rules detailed above a more accurate allocation procedure would be desirable. The procedure adopted by Candler et al. (1974) in their confrontation model work may be appropriate. It would, of course, be necessary to aggregate animal categories to a level

Table 3.20 An Allocation of Coarse Grains between Animal Classes Based on Revised Coefficients

	Pork	Poultry	Dairy	Beef	Allocated	Observed	Residual	Residual
					(000' m. tons)			%
1961	1999	1897	2450	3474	9821	8490	-1331	-16
1962	2019	1898	2406	3520	9842	10551	708	7
1963	2011	1958	2351	3565	9886	11188	1302	12
1964	2173	2086	2324	3836	10420	10901	481	4
1965	2064	2156	2279	4066	10566	11780	1213	10
1966	2081	2280	2192	4269	10823	13161	2337	18
1967	2449	2380	2110	4283	11223	11804	581	5
1968	2412	2374	2048	4273	11107	12356	1249	10
1969	2299	2581	2009	4310	11199	14988	3789	25
1970	2789	2795	1950	4295	11829	15936	4106	26
1971	3190	2739	1948	4438	12315	16982	4669	27
1972	2853	2748	2039	4725	12365	14327	1963	14
1973	2787	2858	2105	5094	12846	15000	2154	14
1974	2759	2848	2178	5406	13193	14520	1327	9
1975	2353	2599	2280	5826	13058	15609	2551	16
1976	2311	2777	2337	6106	13532	13687	156	1

consistent with information provided by the allocation model and this requirement would restrict this approach.

Derived Feed Demands

An alternative method to estimating total feed use treats feed as being a derived input demand. The aggregate quantity demanded is described as a function of the price of the feed itself, the price of a substitute feed input and the price of the product. Prices in this specification are current and feed demands are aggregated with other demands (consumption and stock) in order to simultaneously determine market price. However, the current linkage version (Keyzer, 1980) requires that demand be composed of two components - a committed demand component and a budget share component, the latter essentially being a

Table 3.21 Estimated Derived Feed Demand Equations

1. Wheat:

$$FDWH = \underset{(140.86)}{1283.56} - \underset{(1.996)}{8.783}\ FPWHL + \underset{(0.071)}{0.389}\ FPLiL + \underset{(146.20)}{866.12}\ DLFTS$$

$R^2 = 0.88$ D.W. = 1.82

2. Coarse Grains

$$FDCG = \underset{(4815.63)}{-2583.82} - \underset{(19.16)}{26.50}\ FPCgL + \underset{(2.56)}{4.50}\ FPBFL + \underset{(1.71)}{3.56}\ TLiV + \underset{(946.33)}{2247.36}\ DLFT6$$

$R^2 = 0.86$ D.W. = 2.67

3. Protein Feeds

$$FDPF = \underset{(130.48)}{523.74} - \underset{(0.110)}{0.107}\ FPPFL + \underset{(0.015)}{0.052}\ FPLiL + \underset{(0.042)}{0.205}\ TLiV$$

$R^2 = 0.94$ D.W. = 1.33

4. Other Foods

$$FDOF = -249.75 + \underset{(0.018)}{0.101}\ TLiV$$

$R^2 = 0.70$ D.W. 0.72

5. Dairy Products

$$FDDA = \underset{(111.24)}{-565.60} + \underset{(0.04)}{0.65}\ INDC$$

$R^2 = 0.94$ D.W. 0.88

6. FPLI = FPPK + 0.10 FPPE + 10 FPDA + 1 FPBF

7. TLIV = QPPK + QPPE/0.085 + 0.3 INDC + 1.25 QPBF

function of income. In future it may be possible to devise a procedure that will allow livestock feed demand to be expressed as a function of the appropriate current price variables.

An alternative approach assumes that producers do not react immediately to price changes because of the livestock cycle. Assuming this lagged response it is possible to specify derived feed demand equations that are consistent with requirements of the linkage system. These feed demand equations are presented in Table 3.21. The mnemonic code thereof is noted in the Appendix. Results for these demand equations are generally satisfactory. It is noted that because of the aggregate nature of the livestock sector two proxy variables representing a general index of livestock product prices (FPLIL) and another representing the gross output (TLIV) of the sector were devised. In the demand for feed wheat equation, the variable FPLIL is used. It is highly significant indicating that as livestock product prices rise, there is an increased demand for feed wheat. The own price variable for protein feeds is not significant, perhaps indicating that producers cannot easily adjust their protein feeding requirements to price changes. On the other hand, as the number of animals fed increases total protein demand increases and this demand is also reinforced by livestock prices in the past period.

The approaches detailed are both used depending on the supply module selected. Where the allocation module is used an allocation of feed use between different livestock classes and feed costs is required. Over the forecast period, the allocation model optimizes livestock output or herd sizes and consequently feed use is endogeneously determined. A trade residual is also determined. When the econometric supply module is used livestock outputs and herd sizes are firstly determined, and feed requirements are then calculated. In this supply specification an allocation of feeds between different livestock classes is not required.

3.2.2. Production Function Parameter Estimation Results

Having detailed the manner in which the objective function coefficients and resource constraints for the revised Canadian allocation model are determined we now consider the production functions. Since it is necessary to allow for a 10 to 15 year horizon and because it is unlikely that input/output ratios will remain constant over that period, technical change over time must be allowed for.

In doing so the relationship between the decision variable (A_i) and factor input levels previously specified are rewritten with time varying parameters:

$$A_i = \alpha_{it} K_i^{\beta_{it}} L_i^{\gamma_{it}}$$

where

$$\alpha_{it} = \theta_{it} TK^{\varepsilon_i - \beta_{it}} TL^{1-\varepsilon_{it}-\gamma_{it}}$$

and

$$\beta_{it} = p7_i/(1 + e)^{-tp_{8i}}$$

$$\gamma_{it} = p9_i - \beta_{it}$$

$$\theta_{it} = p5_i \cdot e^{t \cdot p3}$$

$$\varepsilon_i = p6_i$$

$$\gamma_{it} + \beta_{it} = p9_i$$

The parameters $p3_i$, $p4_i \ldots p9_i$ are constants; these are estimated simultaneously using a nonlinear estimation package developed by Fischer. Details of the estimation procedure are reported by Fischer and Frohberg (1980). It is convenient to report the values of these constants rather than the more direct values of the coefficients of the production relationship since the latter are time-dependent. Depending on the value of t differing rates of change over the period may be considered.

The coefficients of the production relationships estimated for the 11 commodities are presented in Table 3.22. The most worrying aspect of these results is that the $p9_i$ parameter is either at the upper or the lower bound for all but two commodities. Various explanations may be advanced, including that a true or "expected" net revenue per unit for each of the activities has not been defined. This aspect is being considered.

Another procedure that may improve these results is to place a larger emphasis upon observed capital and labor allocations to each of the commodities. These allocations of scarce resources should also consider the years when resources may be left idle, for example during the LIFT program years.

Another explanation for these results may involve the methodology chosen. Depending on various assumptions made during the estimation procedure, or on the specific of the allocation model chosen, various estimates of this parameter set have been obtained. The set indicated in Table 3.22 should be tested over the forecast period and its plausibility noted. However, the interactive methdology used is fairly time intensive - (real computer line). The results in Table 3.22 took several months to obtain. Over 100 hours of central processor unit time were required but given the real time involved, one is fairly hesitant to try a respecification of the model. However, given the fairly unsatisfactory values for some of the coefficients the work is still ongoing. The set presented here should be viewed as provisional.

Table 3.22 Coefficients of the Production Relationship

Commodity	p3	p5	p6	p7	p8	p9
Wheat	0.06	9,750.7	1.0	0.11	0.03	0.95
Grains	0.04	27,746.9	0.00	0.12	0.00	0.50
Oilseeds	0.01	15,834.2	0.04	0.12	0.00	0.50
Vegetables	0.03	403.9	0.72	0.10	0.00	0.50
Fruit	0.02	302.4	0.71	0.10	0.02	0.50
Ind.Crops	0.01	76.3	0.66	0.0	0.13	0.50
Roughage	0.03	117,264.0	0.04	0.21	0.04	0.95
Pork	0.01	1,484.8	0.79	0.19	0.06	0.95
Poultry	0.05	1,585.7	0.06	0.11	0.05	0.79
Dairy	0.02	13,917.5	0.00	0.24	0.09	0.81
Beef	0.05	23,374.2	0.11	0.16	0.00	0.95

In addition to production function coefficients for each of the crops, an estimated yield relationship per hectare was derived simultaneously with the estimates of the coefficients of the production functions. Generally, estimated yield is a function of rainfall, the acreage planted to crop i and a time trend. More specifically, the equation is presented as:

$$Y_i = a_i + b_{1i}R_i + b_{2i}S_i + b_{3i}T_i$$

where

Y_i = yield per hectare (m.t), crop i,

R_i = a rainfall index - crop-specific and exogeneous,

S_i = the share of crop i - as this share is increased and more marginal land is used, yield per hectare is expected to fall,

T_i = a time trend attempting to capture technology changes for crop i.

The results for these yield functions are presented in Table 3.23.

Table 3.23 Estimated Yield Coefficients for Crops

Commodity	Constant	T_i	S_i
Wheat	1.80	-0.010	-1.83
Coarse grains	1.26	0.047	-0.07
Oilseeds	0.05	0.005	-0.50
Vegetables	1.83	0.051	-7.50
Fruits	1.80	-0.007	-15.0
Industrial crops	2.47	0.073	-20.0

The basic reason for attempting to estimate yield responses simultaneously and postulating a negative sign for the share variable is based upon experience gained through work on the European Community models. Incorporation of this share relationship has allowed the returns to scale parameter to tend closer to 1. Since this scale parameter generally tended to be less than 0.5 when no bounds on this parameter were set and when no yield function was estimated, we drew upon their experience in attempting to improve this aspect. At this stage certain coefficients for both yield and production relationships remain unsatisfactory.

3.2.3 Some Allocation Model Results

The solution of the non-linear allocation model for each period determines agricultural output for each of the sectors over the historical and forecast periods. In this section some results are presented so that the reader may evaluate the procedures used.

One should note that an optimizing framework has been adopted and that activity levels are unconstrained. The results obtained must be considered vis a vis those of an alternative approach. It is noted that many aggregate linear programming models are often constrained by using bounds, activity ratios or flexibility constraints. It has also been the experience of the authors and others (Johnson, 1981) that callibration methods are often required for econometric models so that forecasts can be reasonably accurate. Our general experience, with the model as specified was that forecasts were surprisingly accurate. Tests over the forecast period are continuing.

In this section we indicate results obtained for the estimation period. Given that the actual level of the various activities is known these levels may be compared to optimum solutions obtained. The allocation model is solved for each of the 16 time periods and in each period the optimum level for the 11 variables is determined. It is difficult to report on ex post estimation period results because of the procedures used in attempting to link the supply, demand and macro components of this work. As noted earlier the agricultural supply module is merely one component and validation tests that are currently proceeding involve all components. That is, we are dealing with a general equilibrium model and it is only through extensive testing that inconsistencies are pinpointed including those of the supply module. An alternative approach involves solving the optimization model alone over the forecast period. However, there is nothing to be learned from this exercise because for a given set of model coefficients an optimum solution is always found and results over the forecast period will be similar to results over the historical period. In other words the coefficients of the production function, although time varying, are relatively constant and therefore the solution obtained depends upon the relative profitability of the alternatives and upon the level of resources. The solution to the problem can only change if the constants of the model change, namely, the objective function coefficients, the resource capacities or the coefficients of the production relationships. Since resource capacities and the production function coefficients vary only slightly over the planning horizon, it is the relative profitability of the alternatives that determines their output level. However, accurate specification of the coefficients of the criterion function, the capital and labour constraints and the coefficients of the production relationships is essential if forecasts of output from the agricultural sector are to be reliable and hence the attention given to these aspects in this work.

To illustrate one set of results, Table 3.24 is presented. The optimum level for wheat acreage is compared to actual acreage. The residual averages 11.4% over the 15 year period. Given the fairly dramatic acreage changes that took place during this period this residual is generally fairly small. As noted from Table 3.24, there is a dramatic drop in planted area from 10.1 million hectars in 1969 to 5.0 million hectars during the LIFT program year of 1970. After 1970, planted area increased slowly reaching its former level in 1976. These changes have been captured in the results indicated. It should also be noted that relative prices are important and, therefore, as indicated by Table 3.24, one cannot predict an acreage increase solely on the basis of a price increase for the commodity in question. It is also sometimes difficult to assess whether errors in predicted output are due to errors in relative prices or due to the coefficients of the production relationships.

The residual over the same period for coarse grains is 13.8%, for pork it is 17.4%, for poultry 3.8%, 7.3% for dairy and 5.6% for beef. The residuals for oilseeds, vegetables, fruits and industrial crops are less satisfactory. In the estimation of the production function parameters, weights used are based upon the relative contribution of each commodity to gross agricultural output. This being the case, greater emphasis is given to deriving coefficients for the production relationships that will allow the residuals for important commodities to be as small as possible.

Table 3.25 indicates results obtained for beef cow numbers. In this instance herd size is estimated and total slaughter or beef marketed is treated as a function of herd size. The residual averages 5.6%. A complete listing of all results for the allocation model is presented in the Appendix.

Table 3.26 indicates the residual for the different commodity groups for 1976. For this particular year the residuals are generally higher than that of the average over all years.

Table 3.24 Observed and Estimated Area of Wheat

	Price ($/m. ton)	Observed Area (000 ha)	Estimated Area (000 ha)	Residual %
1962	70.1	10.8	11.2	3.4
1963	68.8	11.1	11.2	1.2
1964	72.5	12.0	11.1	-7.3
1965	69.3	11.4	12.1	6.0
1966	73.3	12.0	12.9	7.9
1967	73.0	12.1	10.9	-10.3
1968	66.6	11.9	9.5	-20.2
1969	62.4	10.1	10.6	5.5
1970	61.7	5.0	6.0	18.8
1971	61.3	7.8	8.8	12.5
1972	58.6	8.6	6.8	-21.0
1973	79.1	8.5	8.7	-8.5
1974	168.2	8.9	10.7	20.7
1975	164.4	9.4	10.4	10.2
1976	146.3	11.2	9.1	-18.8

Table 3.25 Observed and Estimated Closing Beef Herd Size (1962-1976)

	Price ($/m. ton)	Observed Herd Size (000's)	Estimated Herd Size (000's)	Residual (%)
1962	66	5,276	5,083	-3.7
1963	71	5,661	5,310	-6.2
1964	71	6,002	5,406	-9.9
1965	74	6,019	5,509	-8.5
1966	71	6,023	5,576	-7.4
1967	85	6,056	5,927	-2.1
1968	99	5,951	6,385	7.3
1969	103	6,096	6,650	9.1
1970	102	6,496	6,972	7.3
1971	101	6,981	7,402	6.0
1972	109	7,402	7,942	7.3
1973	121	8,099	8,030	-0.8
1974	141	8,626	8,025	-7.0
1975	183	8,677	8,289	-4.5
1976	229	8,405	8,023	-4.5

Table 3.26 Observed and Estimated Output Levels for 11 Commodities (1976)

		Observed Output	Estimated Output	Residual (%)
Wheat	(000 hectares)	11,252	9,141	-18.8
Coarse grains	"	8,934	11,477	28.5
Oilseeds	"	1,252	1,201	-4.0
Vegetables	"	262	180	-31.3
Fruit	"	74	52	-29.2
Industrial Crops	"	38	16	-57.0
Roughage	"	5,665	5,407	- 4.5
Pork	(m. tons)	531	836	57.6
Poultry	(mt. protein eg.)	105	112	7.0
Dairy	(cow numbers)	1,976	1,806	-8.6
Beef	(herd size)	8,405	8,023	-4.5

It was noted earlier that the procedure involved in estimating the parameters for the production relationships required over 100 hours of central processor time. One is therefore reluctant to try alternative functional forms for the production relationships or respecify the model. Respecification of the allocation model involves derivation of new first order conditions for an optimum and these conditions must then be reformulated into the optimizing code. The algorithm used throughout this study was specifically written for the allocation model as specified. This procedure has an advantage in that an optimum solution to a problem of the given structure may be obtained, generally, more quickly than that for a more general nonlinear programming algorithm. However, the disadvantage of this approach is that the algorithm needs to be rewritten as the structure of the problem is changed and then testing is required to eliminate various allocation errors.

Aside from the algorithm the procedure involved in the estimation of the parameters of the production relationship involves iteration between the optimizing allocation model and the parameter estimation subroutine. Compatibility between the different software packages is essential. The process of ensuring this compatability is slow.

The results presented in this section and the experiences gained while developing this work suggest various improvements that can be made. In particular it was noted earlier that the $p9_i$ parameter often tended towards the bounds. This problem has yet to be resolved. In doing so it is expected that one criterion will involve deriving returns to input factors that fall closer to levels that are observed in practice. Secondly, further attempts to reduce the deviation between observed and estimated output levels will be made. The work should be viewed as an attempt to evaluate an entirely new methodology. As such there are risks and rewards involved.

4. AN ECONOMETRIC SUPPLY SPECIFICATION

The basic linked system has been developed using the allocation procedure described in the previous section to model agricultural supply responses. The work undertaken and described in that section allows a respecified Canadian model to continue to be used as part of the system. In addition to the allocation model approach an econometric model of the agricultural supply sector has also been developed. This section details this work.

In developing this econometric model we have been able to draw upon many studies of a similar nature (Huff, 1980). In particular, the FARM (Food and Agricultural Regional Model) model has provided a useful background. This model may be described as a quarterly forecasting model covering the entire agricultural sector. At the farm level, structural supply response models of the beef, dairy, hog, poultry (eggs, broiler chickens and turkey) and the crop sector (wheat, oats, barley, corn, rapeseed, flaxseed and soybeans) have been specified. The model explicitly determines market equilibrium prices and quantities for 17 of the major grain and livestock commodities. Both the production and marketing systems are described with vertical, spatial and temporal product flows being detailed. Full details of this model are provided in the FARM report (FARM, 1980) and in the many working papers covering this effort (Meilke and Young, 1979; Kulshreshtha, 1979, Low and Petrie, 1979; Coleman, 1979; etc.) Since the publication of these reports development of the FARM model has continued and refinements have been made.

The model developed in this section corresponds to the same commodity list as specified for the allocation model. Various problems have arisen and these are noted. A lack of satisfactory simulation software packages at IIASA prevented extensive testing of these results.

It should also be noted the estimation period covers the years 1961 to 1976. The latter years are unusual in that the agricultural sector was still adjusting to the rather severe price shocks of 1971/72. This fact alone suggests that reestimation of the parameters of the various equations over a larger period is necessary. To do so requires more recent data, but FAO has not updated the original series used by FAP. We report our current results but stress that these do not represent a final set.

Essentially, this work involves an attempt to estimate total agricultural output by commodity for each of the major sectors. The major grain and oilseed crops have been aggregated into three categories (wheat, coarse grains and oilseeds). A second group consists of vegetables and fruits, other food crops and non-food or industrial crops. This latter group is important in terms of the gross value of their output but their area and production tends to follow a strong time trend reflecting the general economic or institutional conditions of these sectors. Shifts in the area planted to wheat, coarse grains and oilseeds and the area summerfallowed are extremely important to Canadian agriculture. An accurate forecasting of these shifts is highly desirable. Some of the past efforts attempting to predict these changes have been successful, others less so.

For livestock supply, four major commodities are considered -- beef, dairy, pork and poultry. In the FARM modelling approach each of these sectors have been specified in detail. Our approach is less detailed. The results indicate that it is desirable to include some of the institutional constraints affecting the dairy and poultry sectors which have been neglected in this study.

In generating a 15 year forecast, it is important to note that various exogeneous variables, available from other sources for the next few quarters or next few years, are not available over a longer term horizon. In a general equilibrium model of the nature developed it is necessary to limit the number of exogeneous variables. In the model, all price responses are homogeneous of degree zero, which is a requirement for linkage with other country models. This requirement has also placed a limit on the number of satisfactory price or policy variables that may be considered. It does, however, have considerable appeal when a long term forecast horizon is being considered and real prices are appropriate.

In specifying the conceptual relationships involved a Nerlovian type supply response is hypothesized. Where substitution between outputs is feasible, a price rise of an alternative commodity is expected to impact negatively, and where no substitution between commodities is considered feasible the commodity's own price alone is considered. A price rise in major inputs is specified as having a negative impact on output. Between wheat, coarse grains and oilseeds, substitution between outputs is considered feasible. At the level of aggregation considered shifts between livestock categories are not readily expected. The supply behavior of farmers is, therefore, to produce more or less of a livestock commodity depending on product prices and costs. Before a producer will shift from one livestock category to the other a fairly major shift in relative prices would be required or, alternatively, through policy intervention a shift between categories may be achieved. Our conceptual model for livestock does not therefore consider the price of an alternative livestock commodity as being highly significant.

4.1 Wheat, Coarse Grains and Oilseeds

Various approaches to estimating total output of wheat, coarse grains and oilseeds may be considered: estimate production directly, estimate area and yield functions separately with production being equal to their product, or alternatively estimate area and production functions separately and then area is used as an input into the total production function. The approach adopted in this study estimates area and yield functions and their product represents total production. A two stage decision process is hypothesized. Firstly, farmers decide on the total acreage to plant and thereby simultaneously decide on the the acreage to be fallowed for that year. The area to plant or fallow is partly influenced by expected prices for the coming season and partly influenced by soil moisture and other agronomic conditions. A second decision concerns the acreage to be planted to each of the individual crops: wheat, coarse grains and oilseeds. The expected relative profitability of each of the alternatives affects this decision.

In modelling this decision process, the total acreage planted to grains and oilseeds is specified to be a function of a lagged weighted prices for wheat, coarse grains and oil seeds. Also, due to the rather extensive nature of Prairie agriculture, the total acerage planted to grains is partly influence by new land being brought into production. The area summerfallowed is specified to be negatively influenced by the area summerfallowed last year, and positively influenced by the inventories of grain which indirectly accounts for expected price conditions. A dummy variable allows for the unusual conditions encountered during the LIFT program year. Results for these estimations are presented in Table 4.1. The numeric code used is noted in Appendix B. Levels of significance for the explanatory variables are generally low but variables have the correct signs.

Table 4.1: Estimated Model Coefficients for Supply Module

1. Total Grains and Oilseeds Acreage

$$\underset{(692.32)}{ACGR = 19447.5} + \underset{(707.14)}{671.07\ FPGRL2} - \underset{(616.01)}{3855.36\ DLFT4} + \underset{(355.97)}{353.03\ LTIME}$$

$$R^2 = 0.81 \quad DW = 2.06$$

2. Summerfallow

$$\underset{(1200.9)}{ACSF = 11525.2} - \underset{(0.11)}{0.09\ ACSFL} + \underset{(0.02)}{0.02\ INGRL} + \underset{(597.1)}{3674.5\ DLFT4}$$

$$R^2 = 0.87 \quad DW = 1.45$$

3. Total Cultivated Acreage

$$ACCA = ACGR + ACSF$$

Given the total planted acreage, share equations are used to estimate the proportions planted to wheat, coarse grains or oilseeds. The oilseed acreage share is treated as the residual. Following Nerlove (1958) farmers adjust their output towards a desired level based on expected future profits but this adjustment is not immediate. In the wheat share equation the variable wheat acreage share lagged (ACWHSL) partly captures this adjustment process. In addition, the expected relative profitability of wheat versus that of coarse grains is measured by variables which specify the total revenue (real and lagged) per acre for each of these commodities (TRWHLR & TRCGLR) and inventories of wheat lagged (INWHL) are expected to have a negative impact on wheat acreage share. As indicated in Table 4.2, these variables are significant and have the correct sign.

It is noted that expected profits are rather naively measured as a lagged total revenue variable deflated by an index of input costs. Estimates of revenue expectation (Appendix C) based on the Box-Jenkins methodology (Box and Jenkins, 1970) were derived and using these adjusted prices, alternative specifications were tried. Initial results were not that satisfactory and therefore the naive price expectations model results have been reported. The task of attempting to specify an approach or methodology to deal with expectations is not that clear (Kantor, 1979). However, given the importance of expectations in accurately forecasting output further attention needs to be given to this problem.

In addition to each of the share equations, expected yields per hectare for wheat, coarse grains and oilseeds are estimated (Table 4.2).

Table 4.2: Wheat, Coarse Grains and Oilseeds Share Equations and Yield Functions

4. Wheat

ACWHS = 0.6161 + 0.348 ACWHSL + 0.128 TRWHLR - 0.243 TRCGLR
(0.0468) (0.089) (0.065) (0.067)
- 0.0000085 INWHL - 0.138 DLFT
(0.0000034) (0.057)
R^2 = 0.90 DW = 2.15

YIWH = 0.433 + 0.020 TIME + 0.02 RAIN + 0.000026 ACSFL
(0.407) (0.008) (0.006) (0.000035)
R^2 = 0.67 DW = 2.38

ACWH = ACGR * ACWHS

QPWH = ACWH * YIWH

5. Coarse Grains

ACCGS = 0.2907 + 0.1734 TRCGLR - 0.1076 TRWHLR + 0.1449 DLFT3
(0.0292) (0.0432) (0.0336) (0.0194)
R^2 = 0.91 DW 1.00

Y1CG = 0.996 + 0.0211 TIME + 0.0082 RN + 0.000036 ACSFL
(0.316) (0.0077) (0.0042) (0.000033)
R^2 = 0.72 DW = 1.87

ACCG = ACGR * ACCGS

QPCG = ACCG * YICG

6. Oilseeds

ACOSS = 0.0227 + 0.000016 ACOSSL + 0.00843 (FPOSLR/FPWHLR)
(0.0208) (0.0000079) (0.00526)
+ 0.095 DLFT
(0.020)
R^2 = 0.81 DW = 1.72

YIOS = 0.15 + 0.004 TIME
R^2 = 0.68 DW = 1.91

ACOS = ACGR * ACCOS

QPOS + ACOS * YIOS

Soil moisture conditions are important to grains and therefore in the case of wheat the previous seasons late fall rainfall and early season rainfall are aggregated and found to be significant. For coarse grains the rainfall during the growing season is signficant. One also expects a difference in yield depending on whether a crop is grown on land after fallow or on stubble. At the aggregate level these effects were not significant. In addition, over time there have been genetic and other technological changes that have resulted in higher yields per hectare and these effects are accounted for by use of a simple time variable. These results are noted in Table 4.2.

4.2. Pork and Poultry

For both pork and poultry output (measured in metric tons of protein equivalent) it was decided that a fairly simple single equation would suffice. Poultry and eggs are presently aggregated, although it would be desirable to disaggregate because of the different institutional and economic structures of the two industries. The decision to aggregate these two sectors is partly based upon the price information (endogeneous world price) provided when the exchange equilibrium is solved. At this level pork, poultry and fish products are all converted to a protein equivalent basis and then a trading price for this aggregate is determined. This treatment is not that desirable from our perspective and special attention will be required for these commodities. However, this being the case there appeared to be little advantage in attempting to detail supply or demand functions for certain commodities when these are not specified in detail by other trading partners. Alternatively, it it would also have been possible to disaggregate both supply and demand for the internal market alone, trade at these levels in the domestic market, and then devise certain aggregation procedures when the international market is entered. This approach may be followed as the work develops. The manner in which they will be treated when a disaggregated market price is to be used. It will require respecification of certain trading or policy rules. In the international market it is expected that the 10 commodity trading list will not be expanded upon the near future. Therefore, more detail regarding supply and demand schedules for pork, poultry and fish for each of the trading nations will not be available.

Aggregate supply schedules for pork and poultry and eggs are presented in Table 4.3. As indicated farmers respond positively to a real price increase in pork (FPPKLR) and the real price of coarse grains has a negative impact (FPCGLR). The level of significance of these variables is fairly low. The estimated relationship for poultry and eggs is unsatisfactory. Given the institutional settings of this industry a different specification is required. Inventories of these commodities represent a proxy in an attempt to model the policy setting behavior of the broiler and egg marketing boards. The price ratio of poultry and eggs relative to that of feed is positive, with an elasticity of 0.07.

4.3 Dairy and Beef

The approach adopted for both the dairy and beef sectors is to attempt to estimate cow or herd size initially, and with this size as given deduce milk yield or beef slaughter.

Table 4.3: Livestock Response Equations

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7. Pork

$$QPPK = -68.71 + 0.902\ QPPKL + 35.02\ FPPKLR - 230.84\ FPCGLR$$
$$(206.92)\quad (0.175) \qquad (20.36) \qquad (107.61)$$
$$R^2 = 0.76 \qquad DW = 2.43$$

8. Poultry and Eggs

$$QPPE = -11.90 + 1.237\ QPPEL + 0.0896\ (FPPELR/FPCGLR) - .0021\ INPEL$$
$$(11.28)\quad (0.144) \qquad (0.0654) \qquad (.00087)$$
$$R^2 = 0.94 \qquad DW = 1.43$$

9. Dairy

$$INDC = 201.32 + 0.906\ INDCL + 81.64\ FPDALR - 62.64\ LTIME$$
$$(395.01)\quad (0.093) \qquad (122.86) \qquad (35.66)$$
$$R^2 = 0.99 \qquad DW = 1.98$$

$$YiDA = 2.44 + 0.307\ FPDALR + 0.065\ TIME$$
$$(0.24)\quad (0.026) \qquad (0.008)$$
$$R^2 = 0.98 \qquad DW = 0.91$$

$$QPDA = INDC * YiDA$$

10. Beef

$$INBC = -2097.52 + 0.975\ INBCL + 249.48\ FPBFLR - 361.96\ FPCGLR$$
$$(518.34)\quad (0.042) \qquad (44.54) \qquad (317.00)$$
$$R^2 = 0.98 \qquad DW = 1.68$$

$$QSTB = 3047.16 + 0.182\ INBCL - 184.34\ FPBFLR + 990.49\ FPCGLR$$
$$(666.58)\quad (0.028) \qquad (59.88) \qquad (371.10)$$
$$R^2\ 0.85 \qquad DW = 1.30$$

$$YiBF = 0.401 - 0.000060\ FPCGL - 0.000022\ QSTB$$
$$R^2 = 0.79 \qquad DW = 1.17$$

$$QPBF = QSTB * YiBF$$

As with broilers and eggs institutional rules regulate output in the dairy sector. Essentially, it may be argued that output for the dairy sector is regulated according to demand conditions. If this conceptual approach was to be followed it requires explicit determination of various demand elasticities by product. This detailed specification of demands for dairy products is not feasible given the current development status of the algorithm, even for a domestic equilibrium for a single country, and consequently a rather simple alternative specification is detailed.

Over time the number of cows milked on farms (INDC) has declined steadily from 2.9 million cows to 2 million cows over the 16 year period ending in 1976. Milk production per cow over the same period has increased from 2.9 million tonnes of milk equivalent to 3.9 million tonnes. These relationships are captured in the equations presented in Table 4.3. A time variable indicates this trend in both herd size and yield and essentially captures the institutional regulations governing the industry. Aside from these rules there is a small response to real price changes. A positive effect for the lagged farm dairy price allows both yield and cow numbers to respond to price increases.

Given the rather predictable trends for both cow numbers and yield over the past, these specifications are satisfactory from one point of view but unsatisfactory if a more volatile or price responsive industry is envisaged. If, on the other hand, the structure of the industry is to remain, as in the past, and, if one is to assume that this will not change, even in the face of shifts in the international scene, then it may be appropriate to specify this industry as shown.

In modelling the beef sector it was decided that rather than a detailed specification (FARM, 1980), attention would be given to the investment decision that ranchers make. The decision on whether or not to build up the herd affects supplies to the market in the short run since heifers and perhaps some cull cows will be retained for breeding purchases. Over the longer run supplies to the market will increase as calves from this larger sized herd are marketed. Aside from the cow-calf operation, feedlot operators also affect supplies to the market by their decisions. Feed prices relative to those of fed cattle are important variables affecting this decision.

The variable, inventories of beef cattle (INBC), indicated in Table 4.3, is a weighted aggegate of both beef cows, yearlings and calves. It includes animals on farms and those on feedlots. Inventories are hypothesized to be positively related to the price of beef (FPBFLR) and negatively related to the price of coarse grains (FPCGLR). An accurate forecast of herd size (inventories) is essential if a reliable model of the beef sector is to be developed.

Following the decision regarding herd size, a certain proportion of that herd will be slaughtered each year (QSTB). Essentially, this proportion is biologically determined as indicated by the highly significant variable, last years ending inventories (INBCL). The negative sign on beef price reinforces the investment decision. That is, with a price increase in beef, ranchers will tend to holdback in order to continue building herd size. They will, on the other hand, increase the number slaughtered if feed grain prices rise.

Having derived the number of animals slaughtered each year, an estimate of carcass yield per slaughtered animal is used in order to calculate total supplies to the market. In this relationship feedlot operators will tend to fatten animals to a lighter weight as prices of feed grains increase and there is also a slightly negative effect as the volume slaughtered increases, implying that a higher percentage are females and are smaller weight carcasses.

The simple model as specified above is an attempt to capture the dynamics of the investment and slaughter patterns in the industry without detailing individual animal classes and with information that will be supplied via the endogeneous variables in the system.

Aside from these major commodities it was also necessary to estimate supply respones for three aggregate commodity groups namely, vegetables and fruit, other food crops and non-food crops. The estimated relationships were generally less satisfactory.

4.4 Simulation Results

The econometric model specified above has been partially tested over the ex post sample period. As noted earlier the estimation period includes 1976 and thereafter one has the advantage of using the period 1977 to the present as an ex post forecast period and up to the year 2000 as an ex ante forecast period. In making these tests of this supply module observed market prices for the different commodities are used for the ex post period. Over the ex ante period market equilibrium prices are determined endogenously in a general equilibrium framework. In doing so exports or imports are held constant at their 1981 levels. Prior to 1981 net imports are set at their observed levels.

This validation procedure tests all components of the model and for this reason it becomes difficult to identify which component or particular equation or parameter thereof may be misspecified. The approach therefore has advantages and disadvantages but was followed mainly because of a lack of a convenient simulation software package. Had this been available an examination of supply responses alone both over the estimation period and forecast period could have been made. This procedure of course requires that all aspects of the model including trade linkage rules and the various policy components be specified. It also makes the validation procedure more difficult because of the many interrelationships involved. Problems that are located may arise because of some misspecification errors or, on the other hand, may be due to simple software errors. It is problems of this nature that make an evaluation a time consuming process.

In implementing these tests the procedure followed was to adapt software developed for the basic linked system (the supply component thereof being the nonlinear allocation model) and to use this to test the modules developed, either that specified for the allocation model or alternatively that for the econometric supply specification. The demand, inventory, policy, non agricultural and other components remain constant for both procedures.

In this evaluation, results of the econometric supply module for the forecast period, up to 1981, are generally satisfactory. Predicted output from the various sectors corresponds fairly accurately to actual output. When this is not the case the deviation may be explained by some exogeneous shock, e.g. weather for the grains. Over a five year ex ante forecast period there appears to be problems in the grains and oilseeds sectors. In particular, the share of the planted acreage going to wheat increases and consequently wheat output is expanded at the expense of coarse grains and oilseeds. Over a longer forecast period this trend is continued. Further testing to determine reasons for these results is continuing.

For livestock, it appears that the dairy herd will become relatively small; yield per cow on the other hand is increasing. This downward trend in cow numbers may be too strong. Output predictions for the other livestock sectors appear reasonable.

These results are not reported here because it is necessary to eliminate problems before doing so. Currently the relative strength shown by the wheat sector is being investigated. Since this strong growth in wheat output affects output responses in other sectors. One really needs to investigate the former response before the latter are evaluated. A strong wheat sector affects the output of coarse grains, this in turn affects feed grain prices (since net exports are held constant at 1981 levels), and a high feed grain price affects each of the livestock sectors differently. The interrelationships involved are complex, as one may expect, and being so the task of validation also difficult.

5. THE DEMAND BLOCK

The demand component is an integral part of the Basic Linked System (BLS). Through it current period prices and commodity consumption levels are determined. This section describes the procedures used to estimate the demand component parameters, provides the estimated demand parameter results for Canada and then evaluates procedures, results and implications.

The Basic Linked System solves for equilibrium prices and individual country consumption and trade patterns, given the pre-determined supply of the 10 commodities in each country, individual country demand functions and country market policy variables. Demand functions for each commodity in each country are confronted with an international price and through the solution algorithm iterates by increments of these prices to an equilibrium. The international prices are modified by exchange rates and country policy variables so as to translate the international prices into equilivalent domestic values.

Design for the Demand Component

To ensure compatability with the rest of the model, the demand component is designed to (i) adhere to the ten commodity set and (ii) to operate in annual increments. The model is a general equilibrium model and thus, commodity definitions must provide complete coverage of the economy. To ensure that the algorithm converges to an equilibrium, the functions must be homogeneous of degree zero.

For the BLS, demand parameters are required for each country for each commodity. The demand system adopted was an extended Linear Expenditure System (LES) approach. However, the results obtained using a simultaneous estimation of the LES were not realistic and, hence, a multi-step procedure was adopted to obtain consistent parameters with a linear expenditure system structure. The steps used to esitmate demand parameters, and which will be described in more detail below, are:

(i) Estimate an extended LES for two goods (agriculture and non agriculture),

(ii) Estimate Engel curves for each of the nine agricultural commodities,

(iii) Minimize the deviation between the LES for agriculture and the sum of the nine agricultural commodities and a calorie constraint,

(iv) Estimate livestock feed demand (and add to food demand),

(v) Estimate a committed demand for all ten commodities,

(vi) Estimate marginal budget shares for all ten commodities.

Two-Sector Linear Expenditure System

The first step to obtain demand coefficients for the BLS was the estimation of an extended LES for agriculture and non-agriculture expenditues. A standardized structure was used for each country and for the developing countries, two income classes were designated. The functional form was:

(1) $P_iQ_i = P_iC_i + B_i\ (Y - P_jC_j) + U_i \quad i = 1,2$ and

(2) $C_{it} = C_i{}^* + G_i\ (Q_{it-1})$

with P_i the price of commodity i,

Q_i per capita quantity consumed of commodity i,

C_i per capita minimum required quantity of commodity i,

C_i^* per capita constant committed quantity of commodity i,

G_i an estimated parameter,

Y total expenditures per capita,

B_i marginal budget share,

U_i a disturbance term.

The agricultural sector coefficients are used to constrain the results from the Engel curve estimation described in the following section.

Engel Curves

Expenditure elasticities for the nine agricultural commodities, were estimated using Engel curves. These expenditure elasticities were required to obtain marginal budget share estimates. The Engel curves were estimated from non-linear functions, using one of the following forms,

(3) $P_iQ_i = a_i(Y70)k_i$

(4) $P_iQ_i = a_i + k_i/Ln(Y70)$

(5) $LnP_iQ_i = a_i - k_i/Y70$

(6) $P_iQ_i = a_i(Y/P10)k_i$

(7) $P_iQ_i = a_i + k_i/Ln(Y/P10)$

(8) $LnP_iQ_i = a_i - k_i/(Y/P10)$

with P_iQ_i per capita expenditures for good i, a_i, and k_i estimated parameters.

Y70 food expenditures in 1970 dollars, and

Y/P10 current food expenditures deflated by non food retail prices.

Consistency of LES and Engel Curve Estimates

Estimated expenditures for the nine agricultural commodities obtained from these Engel curves were adjusted to:

(i) ensure consistency with total agricultural expenditures, obtained from equations (1) and (2)

(ii) limit total food consumption below a maximum daily calorie intake.

The procedure used for this adjustment was to minimize the deviations of (a) the sum of the food expenditures obtained from the Engel curves and the food expenditures obtained from equation (1), and (b) the sum of the estimated calorie consumption and a maximum allowable level. Adjusted expenditure data were then converted to total domestic agricultural food consumption for the countries.

Feed Consumption

Feed consumption per animal unit for beef and other animals for each commodity was estimated from nonlinear functions that included feed and animal prices (Fischer & Frohberg, 1981b). These per unit estimates were multiplied by number of animal units giving total feed consumption. At this stage, total feed consumption expenditures estimated from feed demand equations, plus intermediate consumption, were added to food expenditures for each commodity.

<u>Marginal Budget Shares</u>

The linear expenditure system also requires estimates of the marginal budget shares for each commodity. These values differed from those obtained from the linear expenditure systems equations (1) and (2) because total and committed expenditures now included feed and intermediate consumption expenditures. The marginal budget shares were calculated for each of the ten commodities from information on total commodity expenditures (food and feed), total and committed quantities and retail prices. Using notation similar to equation (1)

(9) $B_{it} = P_{it} (Q_{it} - C_{it})/Y - P_{it}C_{it}$

with B_{it} the marginal budget share,

P_{it} price for commodity i,

Q_{it} total consumption of commodity i,

C_{it} total minimum required quantity of commodity i, and

Y_t total consumer expenditures

The budget shares calculted in (9) are adjusted every period.

<u>Elasticities</u>

Based on the specification in (9), income elaticities can be obtained by:

(10) $N_i = B_i/W_i$

with N_i income elasticity of demand

B_i marginal budget share, and

W_i expenditure share.

Direct price elasticities for each commodity can be calculated from the following formula:

(11) $$E_{ii} = -1+(1-B_i)\frac{C_i}{Q_i}$$

with E_{ii} direct price elasticity of demand,

B_i marginal budget share,

C_i committed expenditures,

Q_i total consumption expenditures.

Cross price elasticities can be calculated from the following formula:

(12) $$E_{ij} = -B_i\frac{P_jC_j}{P_iQ_i}$$

with Eij the cross price elasticity of i^{th} commodity with respect to the j^{th} commodity.

Data Sources

Date used in the demand estimation are largely from the Food and Agriculture supply-utilization accounts. Part of the data are published in FAO Production and Trade Yearbooks and part are unpublished data. These data were aggregated from 600 commodities to the 16 commodity level. Macro-economic data were obtained from the International Labour Organization and the World Bank. Annual data for the period 1961-76 were used for estimation. IIASA obtained price data for agricultural commodities from FAO. These data refer to farm level transactions. To estimate retail prices estimates of a processing margin between farm and retail levels were used. This margin is calcuated in units of the non-agricultural commodity and the quantity is held constant over time. Processing margins were assumed to vary with non-agricultural prices.

Expenditure data for the nine agricultural commodities and also total agriculture include only the farm level value; that is, they exclude the value added in the food and agriculture processing, distributing and retailing (PDR) sector. One exception is the value added in feed processing which is included in total feed expenditures. The value-added from the agricultural PDR sector is included in the expenditure data for the non-agricultural sector.

Model Results

The estimated coefficients for the two-good dynamic linear expenditure systems, equations (1) and (2), are shown in Table 5.1. Both Canadian results and those for all other countries are shown for comparison purposes. These coefficients are the marginal budget shares (B_i), the minimum required quantities (C_i^*) and the habit or persistance parameter (G_i).

Shares of agriculture and non agriculture expenditures were obtained for 1969 and these are shown in Table 5.2 (Columns 1 and 2). As noted above, for agriculture, the value-added outside of the sector has been included in the non-agriculture expenditures. The marginal budget shares from Table 5.1 were divided by these share values to obtain income elasticities. These elasticities are shown for agricultural and non-agricultural goods in column 3 and 4 of Table 5.2.

Table 5.1 Estimated Coefficients, by Country, for Two Sector Demand System

	Marginal Budget Shares		Agriculture		Non Agricultural	
Country	Agriculture	Non Ag.	C_i	G_i	C_i	G_i
Argentina	0.0645	0.9355	272.925	0.067	6.779	0.05
Australia	0.0184	0.9816	185.991	0.287	25.867	0.05
Austria	0.0472	0.9528	222.023	0.200	15.592	0.63
Brazil	0.0117	0.9883	64.636	0.577	25.867	0.05
Canada	0.0218	0.9782	353.921	0	3059.72	0
Egypt	0.1067	0.8933	77.433	0.05	34.481	0.05
Indonesia	0.0730	0.9270	39.079	0	33.691	0
Japan	0.0326	0.9674	20.974	0.946	34.481	1.0
Kenya	0.3672	0.6328	27.197	1.0	53.225	1.0
Mexico	0.0724	0.9276	159.003	0	473.672	0
New Zealand	0.0302	0.9698	139.969	0.721	2264.4	0.270
Nigeria	0.0930	0.9070	67.837	0	33.851	0
Pakistan	0.1909	0.8091	20.133	0.523	34.481	0.05
Thailand	0.1582	0.8418	62.760	0	104.622	0
EEC	0.0371	0.9629	358.547	0	40.25	0

Source: IIASA estimates - T-MATRIX, Dec. 81.

Table 5.2 Expenditure Shares and Income Elasticities, by Country, for Agricultural and Non Agriculture Sectors

	Expenditure Share		Income Elasticity	
Countries	Agriculture	Non Agriculture	Agriculture	Non Agriculture
Argentina	.335	.665	.193	1.407
Australia	.109	.891	.169	1.102
Austria	.165	.835	.386	1.141
Brazil	.327	.673	.036	1.468
Canada	.097	.903	.224	1.083
Egypt	0.416	.594	.256	1.504
Indonesia	.528	.472	.138	1.964
Japan	.171	.829	.191	1.167
Kenya	.419	.581	.877	1.089
Mexico	.231	.769	.313	1.206
New Zealand	.159	.841	.190	1.153
Nigeria	.556	.444	.167	2.043
Pakistan	.397	.603	.481	1.342
Thailand	.358	.642	.442	1.311
EEC	.180	.820	.206	1.174

Source: IIASA Estimates

Engel curves were estimated for the 9 commodities. Six alternative functional forms were used as shown in equations (3) to (8). The estimated coefficients are shown in Table 5.3 for wheat and Table 5.4 for beef. The tables also show the equation selected. No statistical information was available (e.g. standard errors, R_2, etc.) to assess the reliability of the results. In addition, no information was readily available on expenditures or income to calculate elasticities. For those countries where equation 3 or 6 is used the elasticities are the k_i coefficient In other cases, enough information is available to indicate the signs for the elasticities.

Minimum required quantities were expressed as a percentage of the previous years consumption. These estimates are shown in Table 5.5 for each of the 10 commodities and 15 countries. It would appear that IIASA established these judgmentally, given the uniformity across countries. For example, the coarse grain valves for all countries is 0.5.

For 1970, total quantities of human food consumption and domestic prices at the producer level plus processing margins (to calculate retail prices) were used to calculate food expenditures at farm level prices. These are shown in column (1) of Table 5.6. Similarly, feed requirement quantities were also given. These quantities multiplied by retail level prices are shown in Column (2) of Table 5.6. Total expenditure is given in Column (3), the sum of food and feed expenditures. Committed expenditures were obtained by taking coefficients shown in Table 5.5 for Canada and multiplying by total expenditures for each commodity. These estimates of committed expenditures are shown in Column (4). The expenditure

Table 5.3 Estimated Coefficients from Engel Curves, by Country for Wheat

Countries	a_i	k_i	Equation Used
Argentina	4.14	-213.95	5
Australia	4.40	-158.60	5
Austria	5.57	-0.19	3
Brazil	1.63	0.25	6
Canada	3.68	0.05	6
Egypt	3.67	0.11	6
Indonesia	-3.00	1.00	3
Japan	3.65	258.10	5
Kenya	-0.78	0.47	6
Mexico	4.34	1294.60	8
New Zealand	4.14	-623.50	5
Nigeria	4.38	478.09	5
Pakistan	1.14	0.48	6
Thailand	-8.79	1.47	6
EEC	4.12	-577.13	5

Source: IIASA Estimates

Table 5.4 Estimated Coefficients from Engel Curves, by Country for Beef

Countries	a_i	k_i	Equation Used
Argentina	97.00	0	4
Australia	3.92	0.06	6
Austria	0.29	0.40	6
Brazil	2.45	0.09	3
Canada	-99.35	17.95	7
Egypt	1.12	0.21	3
Indonesia	1.10	41.91	8
Japan	-1.11	0.38	3
Kenya	2.94	16.07	8
Mexico	2.46	9.81	8
New Zealand	4.66	374.60	5
Nigeria	1.46	0.10	3
Pakistan	3.60	273.31	5
Thailand	1.03	0.97	3
EEC	3.77	285.50	8

Source: IIASA Estimates.

Table 5.5 Committed Quantities Related to Previous Year's Consumption, by Commodity and Country

	Wheat	Rice	Coarse Grains	Bovine	Dairy	Other Animal	Protein Feeds	Other Food	Other Ag.	Non Ag.
					(Percent)					
Argentina	0.7	0.9	0.5	0.3	0.92	0.9	0.05	0.25	0.95	0
Australia	0.7	0.9	0.5	0.65	0.95	0.85	0.90	0.65	0.40	0
Austria	0.7	0.9	0.50	0.8	0.85	0.70	0.50	0.5	0.90	0
Brazil	0.7	0.9	0.50	0.9	0.95	0.85	0.5	0.95	0.5	0
Canada	0.7	0.2	0.50	0.55	0.95	0.30	0.75	0.55	0.5	0
Egypt	0.7	0.6	0.50	0.9	0.5	0.6	0.3	0.6	0.25	0.5
Indonesia	0.3	0.5	0.5	0.7	0.9	0.9	0.9	0.7	0.15	0.5
Japan	0.7	0.9	0.5	0.6	0.2	0.2	0.5	0.5	0.5	0
Kenya	0.7	0.9	0.5	0.6	0.3	0.9	0.95	0.70	0.90	0
Mexico	0.7	0.9	0.5	0.9	0.9	0.6	0.5	.55	0.5	0
New Zealand	0.7	0.9	0.5	0.95	0.95	0.9	0.6	.85	0.5	0
Nigeria	0.7	0.8	0.5	0.9	0.9	0.7	0.9	0.65	0.9	0.5
Pakistan	0.8	0.7	0.5	0.5	0.6	0.9	0.8	0.7	0.7	0.5
Thailand	0.6	0.7	0.5	0.9	0.9	0.5	0.9	0.3	0.5	0.5
EEC	0.7	0.9	0.5	0.6	0.9	0.8	0.5	0.4	0.5	0
Average Developed	0.7	0.8	0.5	0.69	0.8	0.63	0.62	0.57	0.55	0
Less Developed	0.7	0.8	0.5	0.7	0.8	0.8	0.6	0.6	0.7	0.3
TOTAL	0.67	0.8	0.5	0.70	0.8	0.7	0.6	0.6	0.6	0.2

Source: IIASA Estimates

Table 5.6 Canada: Consumer Expenditures in 1970 ($'000 U.S.)

Commodity	Total Food Expenditures	Total Feed Expenditures	Total Expenditures	Committed Expenditures	Expenditure Share	Marginal Budget Share
Wheat	71.99	509.02	581.01	406.71	.0109	.0035
Rice	8.22	0	8.22	1.64	.0002	.0001
Coarse Grains	11.49	677.28	688.77	344.39	.0130	.0068
Beef	760.20	0	760.20	418.80	.0143	.0068
Dairy	545.29	172.39	717.68	681.80	.0135	.0007
Other Animal	856.20	0	856.20	256.86	.0161	.0119
Protein Feeds	1.98	99.84	101.82	75.03	.0019	.0005
Non-Food Ag.	155.85	0	155.85	77.93	.0029	.0015
Non Ag.	48328.54	0	48328.54	0	.9099	.9599
TOTAL	51526.00	1588.3	53114.30	2766.26	1.0000	.9999

Source: IIASA and Agriculture Canada Calculations share in column (5) is the total expenditure for the commodity divided by total consumer expenditures. From these data, marginal budget shares could be calculated for each commodity using the specification shown in Equation (9). These values are the difference between total and committed expenditures for the commodity divided by the total consumer expenditures minus committed expenditures for all commodities. These marginal budget shares are shown in Table 5.6.

An Evaluation of the Procedures and Results

Initial results obtained at IIASA using the complete linear expenditure system gave "unrealistic results"and, therefore, a more ad hoc approach was used. Agricultural commodity quantities were obtained from Engel curves, minimum required quantities are specified, and marginal budget shares determined. This procedure generates inconsistencies between the two estimation techniques in addition to the less efficient estimates from single equations.

The choice of linear expenditure system may not be the most appropriate. This procedure assumes that all goods are gross compliments (uncompensated cross-price elasticity of demand is negative). For highly disaggregated non-agricultural commodities, such an assumption is unrealistic (Hassan and Johnson, 1976).

The data used are from a single and consistent source. It is not clear whether these commodity data are specified on a crop or calendar year basis and how the north-southern hemisphere data are aligned. There were no direct observations of retail prices to use in the demand equations, and these values were generated from farm prices and a single estimate of value-added. These margins increase as non-agriculture prices do. The data need further verifiction as to their accuracy and whether the estimates of value-added has changed through time as projected.

The linear expenditure system for the agriculture and non-agriculture sectors produced the marginal budget shares for agriculture for Canada of 0.02, near the low point in the range for the developed countries of 0.018 (Australia) to 0.0472 (Austria). For developing countries, these marginal budget shares are generally larger, as expected, and range from a low of 0.011 (Brazil) to 0.367 (Kenya).

In 6 of the 15 countries including Canada, the "dynamic" linear expenditure system is reduced to a normal static model since the habit persistence parameter is zero. For the non-agricultural sector, in seven additional countries, this parameter is set at either 0.5 or 1. Thus, only 5 countries appear to have econometric estimates for this parameter.

In Canada, like most countries, the committed quantities for agricultural commodities were a high percentage of toal commodity consumption (Table 5.5). Exceptions to this, for Canada, were for rice (0.2) and other animals products (0.3). For Canada, and many other countries the committed quantity for the non-agricultural demand, was zero.

From the two sector model the income elasticities for agriculture, for Canada, was 0.224. This was in the middle of the range for developed countries, ranging from 0.169 for Australia to 0.286 for Austria. For developing countries, the range was 0.036 (Brazil) to 0.877 (Kenya). For Canada and other developed and developing countries, these estimates appear very low in comparison with results from other studies. Almost one-half of the country estimates are below 0.20.

Results of the Engel curve estimates for the nine agricultural commodities indicate a number of problems for individual countries. Wheat elasticities appear low for Canada (0.05), and also for Egypt (0.11) and high for Thailand (1.47). There are also sign problems for Austria, Argentina, Australia, New Zealand and the EEC. For rice, the income elsticity appears high Canada for (.87) and also for Argentina (1.02), Kenya (1.19) and Nigeria (1.34). It is negative for Japan and Brazil. For dairy, the income elasticity is negative for Australia, Canada and the EEC and low for Brazil (0.6) and Thailand (0). For non-food agriculture, values are negative for Canada and also for Austria, Brazil, Mexico and the EEC.

While the minimum required quantities were established judgmentally, some unexpected results were obtained. First, a priori, one would expect those commodities with the highest price and income elasticities to have the lowest committed demand. For example, the committed demand for grains should be higher than livestock. Secondly, there should be a strong relationship between those estimates obtained for the non-agricultural sector (Table 5.1) and the ones shown in Table 5.5. Committed demands are expected to be higher for developing than for developed countries. Not all of the results appear to be consistent with these expectations. For example, in Canada committed demand for beef is higher than rice, grains and other agriculture. It is very high for dairy (.95) and protein feeds (.75), for non-agriculture, it is zero. These estimates are similar to theose for other developed countries, except that other animal and rice values are much lower.

There appear to be major discrepancies between committed quantities for non agriculture between Table 5.1 and Table 5.5. In Table 5.5 five countries have a committed demand of 0.5, and for all other countries it is zero. In Table 5.1, the 0.5 estimate appears reasonably close for Nigeria, Egypt, and the zero estimate is close for Argentina, Australia, Brazil. For all other countries, however, these estimates bear little relationship. There appears to be, on average, a consistency by committed quantity estimates for developed and developing countries. In most cases, the percentages for the groups are identical or close. For only three commodities is the developed country committed percentage below those of the developing countries - other animal products, other agriculture, and non-agriculture. The marginal budget shares estimated from equation (9) and reported in Table 5.6 differ from those estimated using the linear expenditure system and reported in Table 5.2.

The income elasticities estimated in equation 10 and reported in Table 5.7 have values, for Canada, which appear low for meats and protein products and high for grains. Price elasticities reported in Table 5.7

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s) This is consistent with K. Saskai (1982) for estimates of 1958-77 where he notes an income elasticity of -1.044 (Table 5.7, p. 13).

Table 5.7 Canada: Demand Elasticities, by Commodity, 1970

	Wheat	Rice	Coarse Grains	Beef	Dairy	Other Animals	Protein Feed	Other Food	Non Food Ag.	Non Ag.	Income Elasticity
Wheat	-.30	0	0	0	0	0	0	0	0	0	.32
Rice	-.01	-.80	0	-.01	-.01	0	0	-.01	0	0	.84
Coarse Grains	0	0	-.50	0	-.01	0	0	0	0	0	.52
Beef	0	0	0	-.45	-.01	0	0	0	0	0	.48
Dairy	0	0	0	0	-.05	0	0	0	0	0	.05
Other Animal	-.01	0	0	-.01	-.01	-.70	0	-.01	0	0	.74
Protein Feeds	0	0	0	0	0	0	-.25	0	0	0	.26
Non Food Ag.	0	0	0	0	-.91	0	0	0	-.50	0	.52
Non Ag.	-.01	0	-.01	-.01	-.01	-.01	0	-.01	0	-1.0	1.05

e_{ij} = elasticity of subgroup i with respect to j^{th} price, calculated at 1970 level.

appear reasonable in comparison with other studies in Canada. Cross price elasticities have values which are small and most are approximately zero. This implies there is little substitution among commodities in demand. These initial results of the Canadian component would suggest that some refinements are needed before these demand coefficients may be used for policy analysis.

6. CANADIAN/WORLD PRICE LINKAGES

Of critical importance in FAP's model system is the link between domestic prices of a country and those of the international market. International price linkages are of particular importance for traded goods but is also important to the world model even if a country is self-sufficient. In attempting to study these linkages for our situation some preliminary analyses are reported.

We have concentrated on products that may be identified and have shied away from tackling problems associated with aggregated commodities; for example, the other foods, nonfood agriculture or nonagricultural commodity categories. Given some of the difficulties encountered it may be easier to attempt linking prices at the 19-commodity level rather than at the 10-commodity level.

At the 19 commodity level of aggregation products are more homogeneous and since domestic price policies or other policy measures are often implemented at a commodity-specific level these can be more accurately specified. Hence, as a starting point in attempting to explain price linkages over the period 1961 to 1976 disaggregated commodity levels may be more appropriate. It will also be useful to study the latter part of this period because commodity prices in the 1970's were more volatile than during the 1960's. In the early 1970's when the world's stocks of wheat and feed grains were drawn down dramatic price increases occurred and these were followed also by sharp increases in livestock prices. Price increases varied from country to country depending on the market forces and depending on the degree of market intervention by governments. It is these movements that need to be understood and captured in the work. An accurate description of past trade practices is particularly important if trade policies are to be endogenized and if reliable forecasts into the future are to be made.

As a starting point, it may also be useful to review some of Canada's trading practices. This requires that Canada's position in GATT (General Agreement on Tariffs and Trade) negotiations be understood. The results of the "Tokyo Round" of multilateral trade negotiations have also been announced and therefore, over the forecast period it will be necessary to attempt to incorporate some of these tariff changes as they become implemented. Our analysis deals mainly with the period 1961 to 1976 and therefore the old rules apply, but it should also be noted that through this period changes in tariffs, quotas, and so forth, also took place and these changes cannot be ignored.

Canada's Agricultural Trade

Over the period 1960 to 1970 the value of agricultural exports averaged $2.45 billion, The agricultural share of total exports averaged 10.7 percent. Agricultural imports averaged $1.79 billion, representing 8.6 percent of the total value of all imports. For 1981 all exports were valued at $81.23 billion, agriculture's share was $8.8 billion. Imports for that year were $78.88 billion with agriculture imports being $5.61 billion. Over the period 1970 to 1981 agricultural exports increased from $1.7 billion to $8.8 billion, a compounded growth rate of 15 percent (Lin & Labrosse, 1980).

Grains have dominated our export market, while vegetables, fruits and imports of tea and coffee (main item under other agricultural products) represented the major category imported items (Table 6.1). Over the period 1970 to 1979, exports of grains, animal feeds, oilseeds, live animals and other animal products have increased while imports of fruits and nuts, vegetables and tea and coffee have also increased.

Table 6.1 Agricultural Commodity Imports and Exports by Commodity Group, 1979

	Exports	Imports	Net
	(Billion $)		
Grain & grain products	50	5	45
Animal feeds	3	1	2
Oilseeds and products	16	10	6
Animals live, meats and other products	18	16	2
Dairy products	2	2	-
Poultry & eggs	-	2	-2
Fruits & nuts	1	21	-20
Vegetables & potatoe seeds	4	12	08
Other agric. products	6	31	-25
TOTAL VALUE	6	5	1

The FAP trading list is fairly compatible with the aggregation of commodities shown in Table 6.1. One notes trading patterns for individual commodities that differ from the aggregate. These net trade positions result not only from supply/demand relationships but also from policies and programs that affect these balances.

Canada is in an exporter position for wheat and other cereals although small quantities of U.S. corn are imported, rice is imported, oilseeds and oilseed products are exported although soybeans and soymeal are imported. For the bovine and ovine meats category the situation varies depending on the relationship between Canadian and U.S. prices. Trade varies significantly depending on whether live or carcass form is being considered and, within carcass form, by cut of meat. Canadian exports of dairy products are mainly skim milk powder, evaporated whole milk or some cheddar cheeses, whereas imports tend to be specialty cheeses. A cheese import quota of 45 million pounds presently exists. FAP's other animal products category includes pork, poultry and eggs and fishery products. Fish products are exported, our trade in poultry and eggs is generally negligible although imports will take place when market shortages exist, and in certain instances breaker eggs will be exported. The main items falling into protein feeds include rapeseed meal, soybean meal, meat meal and fish meal. Again, a generalization is difficult. Meilke (et al.) reports that during the 1970's domestic demand for soybean meal expanded more rapidly than supply and consequently imports grew rapidly from around 100 thousand metric tons in 1970 to 364 thousand m. tons in 1978. On the other hand, the acreage planted to rapeseed and soybeans has grown substantially over the period and exports of rapeseed meal and oil are important (Kulshreshtha, _et al_., 1979). Items falling into the other food category include oils and fats, sugar products, vegetables, fruits and nuts, coffee, cocoa and tea and alcoholic beverages -- in balance, Canada is a net importer of these items. The final category "non-food agriculture" includes clothing and fibres, hides and wool and industrial crops; as indicated in Table 6.2 Canada is a net importer in this category. McSorley (1979) has provided a more detailed breakdown of these trade statistics. To summarize, and recognizing that the situation will vary over time, Canada's leading exports are wheat, barley, rapeseed, live cattle and furs, hides and skins. Fruits and nuts and plantation crops (tea and coffee), vegetables and sugar are the major imports. Also imported are meats and oilseed products.

This very brief review allows one to focus on linkages between Canada and her trading partners. Since Canada is a major exporter of grain and since this commodity is particularly important to her agricultural sector, the link between domestic prices and international prices is extremely important.

Tariffs and Quotas

Not only is it important to identify directions of trade flows, but it is also important to be able to document tariffs and non-tariff barriers that exist between countries for particular products. An aggregation of these tariffs to the required 10-commodity level is expected to be difficult. Some details of the type of tariffs and quotas currently existing between Canada and other countries has been provided by Lohoar (1979). To illustrate, a few examples are chosen:

- Canada allows imports of wheat, barley and oats only under a license from the Canadian Wheat Board,

Table 6.2 Exports and Imports of Agricultural Products by Category, 1976 to 1978

	Exports			Imports		
	1976	1977	1978	1976	1977	1978
			(1000 m.t)			
Grains: net*	15,442	17,521	18,798			
Wheat	10,552	14,268	14,417			
Wheat flour	507	476	652			
Barley	4,329	2,790	3,569			
Corn				792	546	419
Oilseeds: net	645	1,096	1,446			
flaxseed	247	329	410			
soybeans	775	1,028	1,208	397	318	324
Oilseed products: net	380	219	247			
rapeseed meal + oil	177	301	325			
oils				186	147	142
oilcakes + meal				351	354	414
Meats: net				89	45	3
beef and veal	40	36	31	95	56	66
pork	36	43	53			
Mutton + lamb				15	13	14
Dairy prod.: net	96	181	151			
cheese	2	2	2			
skim milk powder	98	166	123	23	22	21
Fruits and nuts: net				1,377	1,350	1,339
Vegetables: net				687	645	707
Other products:						
potatoes	48				62	25
sugar				932	1,095	1,057
coffee				79	68	77
tobacco	26	24	33			
wool				9	8	9

*The net position includes items not shown in this table

- Canada currently has a tariff of 1 cent a pound on live cattle while that of exports to the US is approximately 2 cents,
- US and Canadian tariffs on fresh, chilled or frozen beef and veal are currently 2 cents a pound,
- There are US tariffs on unboned, uncooked pork packed in airtight cartons of 2 cents a pound, and the US has tariffs on cheddar cheeses of 15 to 12 percent,
- Canada currently has a tariff on corn imports of 6.5 cents a bushel (declining to 5 cents in 1987) and 6.5 cents a bushel on malting barley,
- Canada has a tariff on seed and table potatoes currently set at 36.2 cents per 100 pounds.

These tariffs are often country-specific and they often vary depending on whether some bilateral or multilateral agreement is in effect. These considerations are important in our attempt to link Canadian commodity prices with those of trading partners or to the international market.

As a starting point in this analysis, and after allowing for exchange rates and transport costs, it is convenient to consider a simple price linkage equation:

$$PD_i = a_i + b_i \; PW_i$$

where

PD_i is the domestic price of commodity i,

PW_i the world price expressed in domestic currency, and

a_i and b_i represent policy parameters.

In a free market situation where the world price and domestic prices are equal, $a_i = 0$ and $b_i = 1$. If $a_i = 0$ and $b_i > 1$ an *ad valorem* equivalent tariff is applicable, and if $a_i > 0$ and $b_i = 1$ then an absolute or specific tariff equivalent is in effect.

Zwart and Meilke (1979) have argued that the levels of a_i and b_i change over time as world price levels and domestic economic conditions vary. Therefore a_i and b_i measures the net impact of a combination of instruments which are used to relate domestic prices to world prices through domestic pricing policies. Bredahl, Meyers and Collins (1979) used a similar approach in estimating a price transmission equation in which domestic price is a function of world price, the exchange rate and other variables that are hypothesized to explain the policy variables. The coefficient of the world price variable is a measure of the extent to which variations in world market prices are transmitted to the domestic price. Other arguments allow for changes through time in the size of the price transmission coefficient. Thompson (1981) has noted that there is debate in the literature as to whether the exchange rate itself should be handled in a multiplicative fashion or as a separate variable. He reports that various authors have provided empirical evidence to show that changes in the exchange rate have proportionately a greater effect on exports than the same percentage change in world prices change in world prices when the country is large enough to influence international prices. This ought not be a major problem in Canada's case.

The work that follows indicates some initial observations that may be made regarding price linkages. We report on these preliminary results realizing that further explanations are required and that these can only be provided by a more thorough investigation of the problem. In Table 6.3 various series on wheat prices are reported. The world wheat price is on a calendar year basis (in US $). This series is compatible with prices reported on a crop-year basis. An "export price" for both the US and Canada was selected. The Canadian Wheat Board selling price quotation is used as this measure although this series does not correspond to the transactions price. The "pool price" for wheat is a weighted average price for all export and domestic sales handled by the Board. The "farm price" of wheat is a weighted price representing sales passing through the Canadian Wheat Board and those not passing through their control, i.e. "off-board" sales. Since prices were relatively stable before 1972, Table 6.3 presents these series for the period 1970 to 1976 only. These prices moved together but during the downward price movement after 1974 the reported world price series lagged. The FAP world price series has not been updated beyond 1976 and therefore we are unable to examine these series over a longer period when prices fell quite rapidly after 1976 and then recovered. These price movements and their lags, if any, must be captured in the price transmission equations if the objectives of this study are to be accomplished.

Table 6.3 Reported average wheat prices

	World* Wheat Price	World Wheat Price	US #2 Hard Winter Ord. prot. (FOB Gulf Ports)	1CWRS(13.5%) CWB Selling Quotations (Thunder Bay)	Pool Price	Farm Price
			(C.$ m. ton)			
1970	64.7	68.3	62.6	65.1	61.3	52.8
1971	68.6	29.2	63.5	62.0	58.6	49.8
1972	68.3	89.6	73.2	96.5	79.1	68.4
1973	106.0	143.9	139.0	201.8	168.2	164.3
1974	167.2	166.1	175.0	193.4	164.4	154.6
1975	171.9	162.4	151.5	172.1	146.3	132.9
1976	150.8	-	131.3	123.8	117.1	105.4

* Calendar Year - all other price series are for crop year.

Over the period 1970 to 1975 the relationships between the world price of wheat and that of Canadian prices is shown in Table 6.4. The coefficient of 1.09 between the Canadian export price and world wheat price indicates that for a $1 change in world prices there will be a $1.09 change in domestic prices. Quality differences could explain why this coefficient is greater than one. The coefficient of 1.34 for the pool price of wheat appears high but, in general, these relationships are fairly satisfactory and may, therefore, be used in the linked runs.

In Table 6.4 2 sets of results are reported. The first set covers the period 1970 to 1976. The robustness of the results over these two sample periods is examined. Over the longer period, 1961 to 1975, the coefficient for the farm price of wheat (1.02) remains relatively

Table 6.4 Relationship between world wheat price and Canadian wheat prices, 1970 to 1975

Dependent Variable	Constant	World Price	R	D.W.
1. CWB export price (Thunder Bay)	-14.3 (18.6)	1.09 (0.15)	0.92	1.97
2. CWB pool price	-25.5 (24.2)	1.34 (0.19)	0.92	1.74
3. Farm price	-22.54 (22.75)	1.08 (0.18)	0.89	1.99
4. U.S. No. 2	-14.8 (10.2)	1.08 (0.08)	0.97	2.44

stable. Price linkage equations for wheat, coarse grain, protein feeds, beef, dairy and pork and poultry are also presented. For wheat and coarse grains this simple price transmissions equation appears satisfactory and stable, for protein feeds the coefficient over the longer period is 1.15, over the shorter period 1.39. A $1 change in world prices of beef results in a change of $0.73 in Canadian farm prices. Canadian farm prices for beef (Table 6.6) changed from $780/mt in 1961 to $1364/mt in 1976, whereas world prices over the same period moved from $526/mt to $1476 metric ton. It is expected that the coefficient relating these two series would be closer to 1.

Changes in farm prices over the observation period for dairy products and pork and poultry prices are also presented in Table 6.6. Canadian farm prices for dairy products moved from $76 (per m. ton) to $242, world prices from $132 to $219. The resulting coefficient is 1.57,

Table 6.5 Relationship between world and domestic prices

		Constant	World Price	R	DW
Wheat	1.	-13.5	1.02	0.91	1.75
		(8.25)	(0.08)		
	2.	-22.54	1.08	0.89	1.99
		(22.75)	(0.18)		
Coarse Grains	1.	-22.47	1.18	0.96	1.29
		(5.79)	(0.06)		
	2.	-31.93	1.26	0.96	1.60
		(13.88)	(0.13)		
Prot. Feed	1.	-78.39	1.15	0.78	2.22
		(57.16)	(0.17)		
	2.	-191.57	1.39	0.74	2.62
		(173.14)	(0.41)		
Pork	1.	926.13	1.11	0.92	1.43
		(629.08)	(0.08)		
	2.	-2097.12	1.41	0.95	2.55
		(1207.39)	(0.13)		
Poultry	1.	1742.35	0.50	0.86	0.03
		(384.00)	(0.05)		
	2.	-156.76	0.69	0.92	1.95
		(801.53)	(0.08)		
Beef	1.	413.77	0.73	0.91	1.01
		(62.86)	(0.06)		
	2.	502.67	0.64	0.18	1.41
		(193.51)	(0.15)		
Dairy	1.	-170.48	1.85	0.91	2.06
		(24.06)	(0.15)		
	2.	-112.03	1.57	0.91	3.04
		(38.70)	(0.21)		
Pork and Poultry	1.	1152.63	1.01	0.93	1.32
		(565.88)	(0.07)		
	2.	1641.59	1.28	0.96	2.29
		(1071.33)	(0.11)		

Note: 1. 1961-76 period for estimation.

2. 1970-76 period for estimation.

probably a result of the emerging administered pricing regime in Canada coupled with import quotas.

Table 6.6 Canadian Farm Prices versus World Raw Material Level Prices for Livestock Products - 1961 to 1976

	Beef		Dairy		Pork and Poultry	
	Farm Price	World Price	Farm Price	World Price	Farm Price	World Price
			(C. $/m. ton)			
1961	781	516	76	132	5954	4005
1962	884	511	76	140	6182	4447
1963	841	558	77	146	5909	4702
1964	789	647	80	143	5776	4729
1965	813	729	86	141	6945	5073
1966	911	739	97	146	7516	5267
1967	961	726	109	146	6438	5476
1968	953	738	112	150	6531	5568
1969	1061	766	110	160	7449	6244
1970	1092	841	110	151	6721	6217
1971	1154	946	122	146	5452	6240
1972	1273	1096	132	157	7732	7031
1973	1631	1502	160	180	11317	9463
1974	1644	1487	207	184	10567	9495
1975	1450	1562	235	231	13833	11699
1976	1364	1476	242	219	13131	12072

Pork and poultry are aggregated in the FAP model, and a resulting world price for this commodity reported. The coefficient relating world prices to Canadian prices of pork and poultry averaged 1.01 over the long period and 1.28 for the period 1970 to 1976. In Table 6.5 results for pork and poultry disaggregated are also shown. Poultry prices over the more recent period are policy determined, in a fashion similar to dairy products, and for this reason may vary independently of that for world prices. Pork is a commodity freely traded and the resultant price is dependent upon US/Canadian supply/demand relationships. The coefficient of 1.41 for the 1970-1976 period versus that of 1.11 for the entire observation period requires further investigation.

These results may be regarded as point of departure for further analysis. It is generally assumed that when trade takes place a perfectly homogeneous product is traded. It is well known that even for a commodity like wheat there are many different grade, each with its own principal use and generally they are not perfect subtitutes for one another. Also, bilateral or multilateral trade agreements exist and reported prices may not reflect these agreements. Countries will differentiate between their trading partners on political or historical grounds and these practices also result in prices different to world prices. Another important consideration concerns the harvesting and marketing seasons of the Northern and Southern hemispheres which results in flows being of a seasonal nature. Binkley and Revelt (1981) note that in transportation costs cannot and should not be treated as a simple constant. They give examples illustrating the variability in transportation rates that can be found. A more detailed analysis attempting to link domestic and world prices would examine some of these issues, together with others, and thereby explain some of the discrepancies reported in this work.

7. SUMMARY AND CONCLUSIONS

The Food and Agriculture Program (FAP) has as its objective an evaluation of the nature and dimensions of the world food situation over the next 10 to 15 years. It aims to identify factors affecting the world food situation by studying the growth processes of different countries and how national and international policies of both developed and developing nations impact on the situation. The research strategy is to develop economic models of different countries, to link these through international trade and then to study their economies and growth processes. Canada is participating in this study and this report details developmental efforts of a Canadian model.

It is noted that national policies as implemented by governments are of critical importance if one is to accurately understand agricultural and non-agricultural economic development process of a country. Furthermore, over a 10 to 15 year forecast horizon it is useful to attempt to endogenize policy actions such that the directions of economic growth may be studied on an ex ante basis. It is, of course, impossible to incorporate all domestic policies as they have been implemented, but emphasis is given to the more important of these. Marketing board regulations as they affect the dairy and poultry sectors in Canada should be considered and actions of the Canadian Wheat Board noted. Fortunately, Canada is a relatively free trader in many of the commodities of importance in the FAP trading list and, aside from price stabilization programs, which in the past decade have rarely been operative, and marketing board programs, one finds that domestic agricultural policies have generally been less disruptive than policies implemented in many other countries. This has made the task of attempting to empirically detail policy affects a little easier and, if the role of non interference is to continue, the task of looking to the future is also made a little easier. It is also feasible to exogeneously detail certain policies as they may become operative. Research and development effects and technological change elements are captured.

A typical FAP general equilibrium model generally consists of four important components -- the agricultural supply sector, a non agricultural supply sector, a demand or final consumer sector and a government sector. Most of our effort to date has concentrated on attempting to detail an agricultural supply sector and, therefore, this component is reported on. Some details, of the demand estimation procedures as followed for the basic linked model are noted.

Canadian Basic Linked Model

Fischer and Frohberg (1980) have provided details of their basic linked models -- models of individual countries that mainly detail agricultural supply responses and models served initially to test the linkage concepts developed by Keyser (1981). The structure of these models is a

nonlinear optimizing formulation with agricultural capital, labour and fertilizer being allocated between alternatives based on the relative profitability of these alternatives. The production possibility frontier is based upon estimated production functions for 8 aggregate commodities. Dairy and beef outputs are treated as a joint product and pork, poultry and fish outputs are aggregated.

Over the estimation period and over an ex post forecast period output responses to exogeneously given prices were remarkably accurate. Some problems were noted with respect to some of the estimated parameters for the various production functions. The aggregation procedure followed, particularly for the various livestock categories, made it difficult to relate output responses to the Canadian situation where policy rules dictate that dairy and poultry supply responses are fairly rigorously controlled whereas beef and pork supply responses are essentially market driven. Although aggregation is necessary the authors found it difficult to relate to commodities falling into the "other foods of crop origin" and "non-food agricultural crops" categories.

A Revised Canadian Allocation Model

Various changes were made to the Cnadian basic linked model as detailed by Fischer and Frohberg (1980). Land was explicitly considered, livestock production was disaggregated, a revised allocation model was specified and production function parameters re-estimated. Decision variables in the case of major grains and oilseeds involve the acreage to be planted to these crops, in the case of beef and dairy the variable pertains to the size of the herd, for pork and poultry products and for the other commodity groups it involves output levels. Estimates of yield per acre or per animal unit are provided thus quantity produced is the product of yield and acreage or yield and herd size. Resource constraints explicitly detailed consider the agricultural capital stock, the agricultural labour force and the amount of arable land in agriculture. Over time these stocks are adjusted through investment, by migration or through new land being brought into production. Investment or migration rates into agriculture are affected by the profitability of the agricultural sector relative to that of the nonagricultural sector.

In attempting to specify the criterion function of the allocation model attention was directed to the problem of trying to detail variable costs for each of the commodity groups over the estimation period and over the planning horizon. The allocation of feeds to alternative livestock classes was part thereof. A satisfactory allocation procedure is yet to be devised.

Re-estimation of production function parameters for the revised relationships required changes to various software packages. The revised allocation model also required different first order conditions for a maximum and therefore the optimization code was rewritten. The procedures involved in re-estimation of the production function parameters are difficult and the results reported are only partially satisfactory. Several coefficients of the production relationships were either at their upper or lower bound levels. However, supply responses from the allocation model to changes in the relative profitability of the various production alternatives appear satisfactory. For example, the residual (optimal versus actual wheat acreage) for wheat over 15 years averages 11.4%, that for beef herd size averages 5.6%. A respecification of the allocation model may be required in order to overcome some of the problems associated with parameter values falling to their bound levels.

An Econometric Supply Specification

An alternative agricultural supply module to that specified above was estimated using a conventional econometric supply specification. Supply responses of a typical Nerlovian type are hypothesized. Where substitution between outputs is feasible a price rise in the one commodity is expected to impact positively and that of an alternative commodity negatively. A price rise in major inputs is specified as having a negative impact on output. Results for the estimation period appear reasonable but problems have been encountered when projections over a 15 year forecast period are made. Following Johnson (1981) some of the problems noted may be minimized.

The Demand System

Some work on reestimation of demand parameters for a detailed Canadian model has commenced. We reported on coefficients estimated for the basic linked system and compare some of the results for Canada with those of other countries and with other studies.

Using a linear expenditure system the marginal budget share for agriculture versus the non-agricultural sector for Canada was fairly low (0.02). Committed consumption quantities for most commodities were a high percentage of total consumption and results of Engel curve estimates were also questionable. Some of the reported price elasticities appeared reasonable but cross price elasticities were generally very small. These results suggested that further refinements are required.

Canadian/World Price Linkages

Initial results linking Canadian commodity prices with those of the international market are provided. A simple linear function is specified where the parameters thereof are viewed as the net impact of a combination of policy and other variables. The analysis provides some insights into the world price series for the different commodity bundles. It appears that the composition of several commodity bundles have changed over the estimation period.

The estimation period was partitioned in order to examine the robustness of the price linkage coefficients, since commodity prices were fairly unstable over the 1972 to 1976 period. These initial results appear satisfactory for the major grain and oilseed crops. In the case of livestock products where the composition of the bundle traded can vary quite significantly over time, further work is required.

In summary, various component parts of the Canadian FAP model are described and evaluated in this study. Several changes to components of the basic linked model for Canada have been made. The report details work in progress and future directions for this work have been discussed.

Conclusions

"Nowadays, it is fashionable to attack economic models -- the small theoretical ones for being small and abstract; the large, numerical ones for being large and empirical, and both types for being irrelevant" (Augusztinovics, 1982). Bearing in mind these thoughts one realizes that

FAP's task is difficult. The work can only be accomplished through a learning process in which pitfalls are minimized and constructive ideas shared. In participating in FAP's work program the authors have attempted to build a Canadian agricultural model that will be useful not only to the FAP program but useful on a "stand alone" basis to policy makers in Canada. The experienced gained has been both rewarding and frustrating. Rewarding because we believe that work of this nature is essential if some of the longer-run food problems are to be investigated and frustrating because of some of the difficulties that have been encountered.

In attempting to realistically model agricultural supply responses the resource based nature of agricultural production and the role played by technological change has been emphasized. For this reason the allocation model approach received attention and its plausibility was examined. The methodology adopted is unique and the limitations of the approach _vis_ _a_ _vis_ those of the more conventional supply function or mathematical programming methodologies must be assessed. It would appear to the authors that the concept behind FAP's approach, that of allowing individual nations to choose their own methodology in attempting to represent their countries economy is sound but the task of developing those detailed country models is difficult. Furthermore, the task of trying to maintain and update this system and perform simulations in a linked run without relying on the presence of the model builders themselves is also extremely difficult. It was for this reason that time was spent examining the basic allocation model developed for Canada. Since forecasts from this model compared very favourably with forecasts made by other agencies it was decided that the allocation model and the methodology used should be examined. The reporting deadline for the FAP work program indicates that the basic linked models of individual countries will form the critical core of the entire model system and that "detailed" country models which are linkable and have been thoroughly tested will be a minority. Our effort at attempting to improve the basic linked model for Canada and attempting to modify it as necessary considered these aspects. The resultant product should be viewed as an approximation of a very complex agricultural system.

The basic FAP concept of linking various countries in an international trade setting but allowing for national governments to assert their own priorities cannot be faulted. In this context the authors and various supporting institutions in Canada have supported IIASA and, in particular, the FAP research program. The work is continuing and the entire framework is being improved as other participating countries continue to develop and test either their own detailed country models or those of the basic linked system. In its current stage of development the system of country models and the linkage algorithm developed by Keyzer (1981) is viewed by the authors as being one of the most developed and realistic representation of the world agricultural system. This achievement should not be overshaddowed by some of the difficulties reported.

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APPENDIX A

Results for the final set of production function parameters selected for the allocation model are presented in this section. It has been noted that starting values for the parameters are selected and through the iterative procedure devised by Fischer and Frohberg a final set is finally determined. The values of these have been presented in Table 3.22. The results presented in this section indicate the optimum output levels of the allocation model for each of the 15 years for each commodity. The values of A_i (Tabled AC in the print-outs) indicate the optimal solution value of A_i from the allocation model. These optimum values may be compared with the observed values of A_i (labeled ACO) and the residual deviation as a percentage calculated (tabled A-RES). In the first year (1962) for the first commodity (wheat) the observed harvested area was 10,852 (000') ha, the optimal value as calculated from the nonlinear maximization model was 11,218 ha, a deviation of 3.4%. A brief definition of the various variables is presented and then a comment on these results follows:

Table 1:	TAREA	-	total cultivated land area (000 ha)
	TLAB	-	total agricultural labor force (000)
	TCAP	-	total agricultural cap (1970 C $ mil.)
Table 2:	SL	-	shadow price of scarce labor
	SK	-	shadow price of scarce capital
	SA	-	shadow price of scarce land
	SR	-	shadow price of roughage constraint

Tables 3 to 13:	PRICE	-	expected price per unit of A_i
	ACO	-	the observed A_i
	AC	-	the optimal A_i^*
	A-RES	-	the deviation $(A_i^*-A_i)$ as percentage
	YCO	-	observed yield per unit of A_i
	Y	-	estimated yield per unit of A_i
	Y-RES	-	the residual as a percentage
	KCO, KC and K-RES	-	as above for capital
	LCO, LC and L-RES	-	as above for labor
	BCO	-	a constant added to yield to normalize for weather variations

The commodity index (i = 1...11) follows that defined in the allocation model. The residuals as tabled are generally fairly low, for wheat an average of 10.1%, for coarse grains 13.1%, for oilseeds they are unsatisfactory at 31.8%, for the first livestock commodity, pork (commodity No. 8), 15.0%, for poultry 3.8%, for dairy cow numbers 8.1% and for the beef herd size 6.1%. By incorporating different assumptions it is possible to continue to try and improve upon these results, but the parameters as presented in Table 3.22 are currently being used. The percentage errors indicate the range of errors to be expected. A true test as to the usefulness of these estimates is also provided through a series of simulations in which responses to price changes are examined. It has been the experience of those familiar with this methodology that the higher the value of the $P9_i$ parameter, the higher the elasticity of supply. These tests are proceeding for this set of parameter values.

APPENDIX B

Definitions of Data

(An L will imply lagged one period when used as last letter of mnemonic).

Mnemonic	Short Definition	Units
ACCG	Area of coarse grain in Canada	('000 ha)
ACCGS	Share of area cultivated to coarse grains (ACCG/ACGR)	('000 ha)
ACCP	Area of cultivated crops in Canada	('000 ha)
ACGR	Area of grains and oilseeds in Canada	('000 ha)
ACOS	Area of oilseeds in Canada	('000 ha)
ACOSS	Share of area cultivated to oilseeds (ACOS/ACGR)	('000 ha)
ACSF	Area of summer fallow in Canada	('000 ha)
ACWH	Area of wheat in Canada	('000 ha)
ACWHSC	Share of area cultivated to wheat, (ACWH/ACGR)	('000 ha)
DLFT	Dummy variable for LIFT policy year	('000 ha)
FDCG	Feed use of coarse grains	('000 mt)
FDPF	Feed use of protein feed	('000 mt)
FPBF	Farm price of beef	($/mt)
FPCG	Farm price for coarse grain	($/mt)
FPCGLR	Farm price of coarse grains, lagged one period, deflated by farm input price index (cost)	($/mt/index)

Mnemonic	Short Definition	Units
FPCGR	Farm price of coarse grains deflated by farm input price index	
FPCGT	Distributed lag on farm prices for coarse grains (t-1 is 0.5, t-2 is 0.3 and t-3 is 0.2)	
FPDA	Farm price of dairy products	($/mt)
FPDALR	Farm price of milk, lagged one period, deflated by farm input price index	($/mt/index)
FPGRL 2	Farm price of grains (wheat and coarse grains), lagged one period, deflated by farm input price index (COSTL)	($/mt/index)
FPGRLR	Farm price of grains (wheat and coarse grains), lagged one period, deflated by farm input price index (COSTL)	($/mt/index)
FPOS	Farm price for oilseeds	($/mt)
FPOSLR	Farm price of oilseeds, lagged one period, deflated by farm input price index (costL)	($/mt)
FPPE	Farm price of poultry and eggs	($/mt/protein)
FPPELR	Farm price of beef, lagged one period, deflated by farm input price index	($/mt/index)
FPPELR	Farm price of poultry and eggs, lagged one period, deflated by farm input price index	($/mt/index)
FPPKLR	Farm price of pork, lagged one period, deflated by farm input price index	($/mt/index)
INBF	Inventory of beef cows and calves on farms	('000 head)

Mnemonic	Short Definition	Units
INCG	Inventory of coarse grains	('000 mt)
INDA	Inventory of dairy cattle and calves on farms	('000 head)
INGR	Inventory of all grains	('000 mt)
INPE	Inventory of poultry and eggs	('000 mt prot.eq.)
INWH	Inventory of wheat	('000 mt)
LTIME	Log of time where 1961=1, 1962=2	
QPBF	Total production of beef	('000 mt)
QPCG	Total production of coarse grains	('000 mt)
QPDA	Total production of milk	('000 mt)
QPOS	Total production of oilseeds	('000 mt)
QPPE	Total production of poultry and eggs	('000 mt prot.eq.)
QPPK	Total production of pork	('000 mt)
QPWH	Total production of wheat	('000 mt)
QSTB	Quantity of beef animals slaughtered	('000 head)
RAIN	Index of late fall and early spring rain	(inches)
RN	Rainfall during growing season	(inches)
TIME	Where 1961=1, 1962=2	
TRCGLR	Total revenue per ha for coarse grains (FPCG and YICG), lagged one year, deflated by farm input price index	($/ha/index)
TRWHLR	Total revenue per ha for wheat (FPWH and YIWH), lagged one year, deflated by farm input price index	($/ha/index)

Mnemonic	Short Definition	Units
YIBF	Dressed carcass weight for beef animal slaughtered	(mt/animal)
YICG	Yield per ha for coarse grains	(mt/ha)
YIDA	Milk yield for cow per annum	(mt/cow)
YIOS	Yield per ha for oilseeds	(mt/ha)
YIWH	Yield per ha for wheat	(mt/ha)

APPENDIX-C

Expected Prices - An alternative Specification

Initally, in estimating farmer responses to price changes, a standard Nerlovian approach has been used. The results using this approach have been presented. As an alternative to this formulation we have also experimented with a more elaborate price expectation model. A Box-Jenkins ARIMA model is specified; the results of which are noted in this section. Given some of the difficulties noted earlier, the Box-Jenkins (1970) methodology and the results may also be tested in the linked mode to provide supply responses for the farm sector. This validation process is currently being undertaken. The results presented here are for expected prices only; for each of the various commodities these expected prices may be used and their plausibility tested.

Generally, a Box-Jenkins autoregressive integrated moving average of order process ARIMA (K,L), with an autoregressive part of order K and a moving average part of order L, is written as:

$$P^*_t = \mu + \sum_{i=1}^{K} \psi_i P_{t-i} + W_t + \sum_{j=1}^{L} {}_jW_{t-j}$$

where P_t is the time series itself and where W_t is the white noise or random disturbance in period t; ψ_i and V_j are parameter values to be estimated and W_t is given as $Q_t = P_t - P^*_t$; that is, the observed value less the expected value.

A time series constituting a discrete linear stochastic process of X_t may be written as:

$$x_t = \mu + \psi_o \varepsilon_t + \psi_1 \varepsilon_{t-1} + \psi_2 \varepsilon_{t-3} + \ldots$$

where μ is a constant determining the level of the time series process and ψ_i are the weights attached to the random disturbances of the different time periods. Where a given time series is stationary it will fluctuate randomly about a constant mean; if it is unstationary it does not have a natural mean. Some non-stationary series may also be reduced to a stationary series (using various degrees of differencing, d). The number of parameters estimated varies depending on chosen i where $\psi_i(i = 1 \ldots n)$, V_i and d. For each commodity an ARIMA scheme estimating P_t as a function of past series (prices) and white noise values was performed. The selected values for ψ_i, V_i and d were as follows:

(ψ_i, V_i, d) : (1,1,0), (1,2,0), (2,1,0), (1,1,1), (1,2,1), (2,1,1)

The best from these six schemes was selected by checking the stationary conditions of the estimated series and by making an X^2 test on the residual autocorrelations. For each of the commodities an expected value (P*) in period t is given as $P^*_t = P_t - W_t$. The values of these parameters are given in Table 1. To illustrate, the expected price for wheat is given as

$$P^*_t = 0.602P_{t-1} + 31.302 + 0.388W_{t-1} + W_t$$

where $W_t = P_t - P^*_t$. The values of W_t for three years (1974, 75 and 76) are indicated.

For each of the commodities for each of the years the observed price, the expected price and the random disturbance value are given in Table C2 to C4. These series provide an interesting comparison of the difference between observed and expected prices using the Box-Jenkins methodology. We have estimated supply responses using these expected prices instead of the Nerlovian model specified and will evaluate these over the *ex post* forecast period (1977 to 1981). Over the historical period (1961 to 1976) results are comparable to those reported in the previous section. It might also be advantageous to reestimate the parameters of the production functions reported on in Section 3 using these expected prices.

Table C.1: Box-Jenkins ARIMA Process Schemes and Results of Expectation Function Estimations:

Variable Π_t	ARIMA Scheme	ψ_1	ψ_2	μ	V_1	V_2	W_{1974}	W_{1975}	W_{1976}	x^2
Wheat Price	110	0.602		31.302	+0.388		-9.33	12.24	-10.6	0.84
Coarse Grains Price	200	1.379	-0.709	22.39			-17.94	10.80	-2.90	0.88
Oilseeds	110	0.772		71.03	-0.140		-46.23	-1.90	+117.04	1.80
Pork	200	0.895	0.028	63.33			-56.24	397.44	-23.21	1.87
Poultry & Eggs	100	0.979		103.86			565.39	192.16	556.15	2.58
Dairy	220	1.228	-0.429	23.17	+0.92	+0.40	27.33	11.74	-23.69	1.64
Beef	200	1.398	-0.536	168.41			-17.56	-92.61	-36.22	3.43

NOTES:

$Pt = \psi_{t-1} + \psi_2 P_{t-2} + \mu + V_1 W_{t-1} + V_2 W_{t-2} + W_t$

μ = a constant equal to the mean of the series if d = 0

W_t = white noise in time t

degrees of freedom = number of observations (16) - number of parameters

x^2 = based on the residual autocorrelations

Table C.2: Observed and Expected Prices Using Box-Jenkins ARIMA Process

	Wheat			Coarse Grains			Oilseeds		
	Observed	Expected	Diff.	Observed	Expected	Diff.	Observed	Expected	Diff.
	($/mt)								
1962	61	69	-8				261	267	-6
1963	64	65	-1	48	52	-4	274	273	0
1964	59	69	-11	52	55	-3	262	283	-21
1965	62	62	-1	55	59	-5	227	276	-49
1966	65	68	-3	58	61	-6	218	253	-35
1967	60	69	-9	51	60	-9	197	244	-47
1968	49	64	-14	46	54	-8	254	230	24
1969	47	55	-9	44	49	-5	238	264	-28
1970	53	56	-3	46	51	-5	223	258	-35
1971	50	62	-12	43	54	-12	214	248	-34
1972	68	56	12	68	48	19	284	241	43
1973	165	77	87	127	86	41	646	284	361
1974	155	164	-9	131	149	-18	473	519	-46
1975	133	121	12	124	113	11	441	443	-2
1976	105	116	-11	97	100	-3	529	412	117

Table C.3 (continued)

	Pork			Poultry and Eggs		
	Observed	Expected	Diff.	Observed	Expected	Diff.
			($/mt)			
1962				4331	4184	146
1963	603	648	-45	4388	4347	41
1964	589	621	-32	4298	4403	-105
1965	723	608	115	4445	4315	130
1966	781	727	54	5025	4459	566
1967	665	783	-118	4268	5027	-759
1968	668	681	-13	4427	4285	141
1969	771	680	91	4775	4441	338
1970	701	772	-71	4110	4782	-672
1971	556	713	-157	3895	4131	-235
1972	809	581	228	4434	3920	514
1973	1184	803	380	6779	4448	2330
1974	1090	1146	-56	7311	4746	565
1975	1470	1072	397	7459	7267	192
1976	1387	1410	-23	7968	7412	556

Table C.4 (continued)

	Dairy			Beef		
	Ob-served	Ex-pected	Diff.	Ob-served	Ex-pected	Diff.
			($/mt)			
1962						
1963	71	82	-11	923	1081	158
1964	74	70	4	886	927	-41
1965	71	83	-12	924	912	12
1966	85	69	16	994	985	9
1967	99	107	8	1068	1062	5
1968	103	107	-4	1033	1128	-95
1969	102	100	-2	1144	1040	104
1970	101	104	-3	1178	1241	-36
1971	109	101	8	1255	1201	53
1972	121	120	1	1357	1291	66
1973	141	129	12	1731	1392	338
1974	183	157	27	1843	1861	-17
1975	229	217	12	1724	1817	-93
1976	224	248	-24	1554	1590	-36

APPENDIX D

Computer Printouts

YEAR	TAREA	TFERT	TLAB	TCAP	TBCAP
1962	24530.	0.	660.00	5935.0	0.
1963	24982.	0.	649.00	6095.0	0.
1964	25414.	0.	630.00	6356.0	0.
1965	25565.	0.	594.00	6383.0	0.
1966	26864.	0.	544.00	6853.0	0.
1967	26570.	0.	559.00	7332.0	0.
1968	26461.	0.	546.00	7815.0	0.
1969	25591.	0.	535.00	7758.0	0.
1970	22317.	0.	511.00	7585.0	0.
1971	26489.	0.	510.00	7298.0	0.
1972	25368.	0.	481.00	7424.0	0.
1973	26514.	0.	467.00	7822.0	0.
1974	25676.	0.	473.00	8465.0	0.
1975	26242.	0.	479.00	9603.0	0.
1976	27477.	0.	474.00	10535.	0.

Shadow Prices :

YEAR	SF	SL	SK	SB	SA	SR
1962	0.	1.3088	0.13469d-01	0.	0.19216d-01	0.28927d-01
1963	0.	1.6494	0.16556d-01	0.	0.20576d-01	0.32390d-01
1964	0.	2.4273	0.22922d-01	0.	0.54423d-02	0.22190d-01
1965	0.	2.6344	0.23835d-01	0.	0.73779d-02	0.24991d-01
1966	0.	3.2109	0.25380d-01	0.	0.	0.20754d-01
1967	0.	2.7434	0.20724d-01	0.	0.	0.17067d-01
1968	0.	3.3289	0.23311d-01	0.	0.	0.20003d-01
1969	0.	3.5226	0.24798d-01	0.	0.	0.20498d-01
1970	0.	3.7314	0.26341d-01	0.	0.	0.21104d-01
1971	0.	3.5369	0.26103d-01	0.	0.	0.19265d-01
1972	0.	3.3054	0.23259d-01	0.	0.	0.17471d-01
1973	0.	5.1073	0.33105d-01	0.	0.	0.25929d-01
1974	0.	7.4480	0.43922d-01	0.	0.	0.36123d-01
1975	0.	7.6167	0.39827d-01	0.	0.19814d-01	0.55270d-01
1976	0.	11.275	0.53286d-01	0.	0.14116d-01	0.64791d-01

Model Results for Commodity 1 :

Year	PRICE	ACO	AC	YO	Y	BCO	BC	KCO	KC	LCO	LC	Y-RES	A-RES	B-RES	K-RES	L-RES
1962	0.07010	10852.	11218.	1.4184	1.6505	0.69454	0.	830.90	804.65	138.60	128.00	16.4	3.4	0.	-3.2	-7.6
1963	0.06880	11156.	11295.	1.7651	1.7513	0.79561	0.	853.30	861.38	136.29	131.63	-0.8	1.2	0.	0.9	-3.4
1964	0.07250	12018.	11139.	1.3604	1.5981	0.62689	0.	889.84	907.90	132.30	128.59	17.5	-7.3	0.	2.0	-2.8
1965	0.06930	11453.	12144.	1.5432	1.7931	0.89893	0.	893.62	1055.8	124.74	141.17	16.2	6.0	0.	18.1	13.2
1966	0.07330	12016.	12964.	1.8739	1.7149	0.84439	0.	959.42	1192.5	114.24	137.28	-8.5	7.9	0.	24.3	20.2
1967	0.07330	12139.	10930.	1.3238	1.5260	0.53484	0.	1026.5	1079.3	117.39	117.05	15.3	-10.3	0.	5.1	-0.3
1968	0.06660	11908.	9503.9	1.4855	1.6030	0.52603	0.	1094.1	993.61	114.66	98.490	7.9	-20.2	0.	-9.2	-14.1
1969	0.06240	10101.	10656.	1.8084	1.8557	0.89339	0.	1086.1	1192.1	112.35	117.15	2.6	5.5	0.	9.8	4.3
1970	0.06170	5052.0	6004.0	1.7862	2.0256	0.80319	0.	1061.9	1023.1	107.31	99.450	13.4	18.8	0.	-3.7	-7.3
1971	0.06130	7853.0	8836.3	1.8352	1.8523	0.75788	0.	1021.7	1112.1	107.10	111.50	0.9	12.5	0.	8.8	4.1
1972	0.05860	8640.0	6821.7	1.6799	1.7332	0.53013	0.	1039.4	891.09	101.01	84.056	3.2	-21.0	0.	-14.3	-16.8
1973	0.07910	9575.0	8762.4	1.6876	1.8632	0.78269	0.	1095.1	1250.3	98.070	107.23	10.4	-8.5	0.	14.2	9.3
1974	0.16820	8934.0	10786.	1.4881	1.5885	0.68183	0.	1185.1	1718.6	99.330	132.38	6.7	20.7	0.	45.0	33.3
1975	0.16440	9487.0	10454.	1.8001	1.7017	0.76506	0.	1344.4	1795.6	100.59	121.10	-5.5	10.2	0.	33.6	20.4
1976	0.14630	11252.	9141.5	2.0962	1.9636	0.91655	0.	1474.9	1672.4	99.540	100.68	-6.3	-18.8	0.	13.4	1.1

Model Results for Commodity 2 :

Year	PRICE	ACO	AC	YO	Y	BCO	BC	KCO	KC	LCO	LC	Y-RES	A-RES	B-RES	K-RES	L-RES
1962	0.04700	7488.0	6964.6	1.7804	1.6433	0.34973	0.	593.50	559.83	99.000	90.023	-7.7	-7.0	0.	-5.7	-9.1
1963	0.04800	7400.0	6976.3	1.8730	1.7837	0.44288	0.	609.50	540.80	97.350	84.820	-4.8	-5.7	0.	-11.3	-12.9
1964	0.05200	6647.0	7677.3	1.7384	1.7897	0.40369	0.	635.60	661.89	94.500	97.669	3.0	15.5	0.	4.1	-3.4
1965	0.04800	7172.0	6739.4	1.9416	1.9127	0.47691	0.	638.30	521.42	89.100	73.717	-1.5	-6.0	0.	-18.3	-17.3
1966	0.04900	7583.0	6009.6	2.0454	1.8510	0.36547	0.	685.30	478.66	81.600	59.120	-9.5	-20.7	0.	-30.2	-27.5
1967	0.05300	7614.0	8064.0	1.7452	1.7670	0.24026	0.	733.20	809.27	83.850	95.522	1.2	5.9	0.	10.4	13.9
1968	0.05600	7933.0	8741.5	2.0234	1.9889	0.41722	0.	781.50	969.38	81.900	106.07	-1.7	10.2	0.	24.0	29.5
1969	0.05400	8233.0	8036.3	2.0539	1.9365	0.31668	0.	775.80	768.02	80.250	84.482	-5.7	-2.4	0.	-1.0	5.3
1970	0.05000	8479.0	7700.4	2.2100	2.0682	0.40377	0.	758.50	680.13	76.650	75.023	-6.4	-9.2	0.	-10.3	-2.1
1971	0.04600	10261.	7748.4	2.3041	2.0623	0.34711	0.	729.80	609.04	76.500	70.234	-10.5	-24.5	0.	-16.5	-8.2
1972	0.04400	9203.0	8090.4	2.1828	2.1107	0.35055	0.	742.40	682.21	72.150	75.011	-3.3	-12.1	0.	-8.1	4.0
1973	0.04700	9182.0	6464.4	2.1231	2.2569	0.44436	0.	782.20	449.19	70.050	45.496	6.3	-29.6	0.	-42.6	-35.1
1974	0.05500	8936.0	5762.1	1.8424	2.2819	0.42107	0.	846.50	356.62	70.950	32.862	23.9	-35.5	0.	-57.9	-53.7
1975	0.08200	8596.0	8895.8	2.2232	2.3379	0.43845	0.	960.30	872.78	71.850	71.311	5.2	3.5	0.	-9.1	-0.8
1976	0.12700	8934.0	11477.	2.2694	2.3020	0.36129	0.	1053.5	1498.5	71.100	110.65	1.4	28.5	0.	42.2	55.6

Model Results for Commodity 3 :

Year	PRICE	ACO	AC	YO	Y	BCO	BC	KCO	KC	LCO	LC	Y-RES	A-RES	B-RES	K-RES	L-RES
1962	0.50080	871.00	1193.7	0.18485	0.17510	0.14501	0.	118.70	49.454	19.800	7.4371	-5.3	37.1	0.	-58.3	-62.4
1963	0.51890	1034.0	1657.9	0.17215	0.20959	0.18363	0.	121.90	101.71	19.470	14.918	21.8	60.3	0.	-16.6	-23.4
1964	0.57670	1276.0	1709.9	0.16771	0.19761	0.16738	0.	127.12	120.77	18.900	16.666	17.8	34.0	0.	-5.0	-11.8
1965	0.53440	1715.0	1689.2	0.17901	0.23329	0.19774	0.	127.66	133.21	17.820	17.613	30.3	-1.5	0.	4.4	-1.2
1966	0.54680	1609.0	1211.8	0.18583	0.20229	0.15154	0.	137.06	86.772	16.320	10.023	8.9	-24.7	0.	-36.7	-38.6
1967	0.54610	1295.0	900.55	0.17838	0.16070	0.09962	0.	146.64	49.839	16.770	5.5016	-9.9	-30.5	0.	-66.0	-67.2
1968	0.47180	1394.0	1123.0	0.18580	0.23452	0.17299	0.	156.30	97.147	16.380	8.9178	26.2	-19.4	0.	-44.2	-45.6
1969	0.53790	2019.0	949.22	0.17385	0.20024	0.13131	0.	155.16	64.811	16.050	6.6672	15.2	-53.0	0.	-58.2	-58.5
1970	0.52120	3224.0	2697.1	0.20316	0.19918	0.16742	0.	151.70	89.583	15.330	9.2412	-2.0	-16.3	0.	-40.9	-39.7
1971	0.49230	3191.0	2529.9	0.20432	0.19309	0.14392	0.	145.96	77.734	15.300	8.3833	-5.5	-20.7	0.	-46.7	-45.2
1972	0.47470	2182.0	848.03	0.22090	0.23027	0.14535	0.	148.48	61.943	14.430	6.3695	4.2	-61.1	0.	-58.3	-55.9
1973	0.67800	2239.0	1145.0	0.21081	0.26902	0.18425	0.	156.44	128.51	14.010	12.173	27.6	-48.9	0.	-17.9	-13.1
1974	1.2603	2183.0	1502.5	0.18323	0.25641	0.17459	0.	169.30	244.36	14.190	21.058	39.9	-31.2	0.	44.3	48.4
1975	1.4874	2564.0	1663.4	0.21412	0.26591	0.18180	0.	192.06	338.43	14.370	25.860	24.2	-35.1	0.	76.2	80.0
1976	1.6456	1252.0	1201.9	0.24281	0.24846	0.14930	0.	210.70	200.77	14.220	13.865	2.3	-4.0	0.	-4.7	-2.5

Model Results for Commodity 4 :

Year	PRICE	ACO	AC	YO	Y	BCO	BC	KCO	KC	LCO	LC	Y-RES	A-RES	B-RES	K-RES	L-RES
1962	0.48900	225.00	226.34	1.7800	1.8208	0.	0.	332.36	114.02	36.960	22.294	2.3	0.6	0.	-65.7	-39.7
1963	0.48300	231.00	187.61	1.6433	1.8844	0.	0.	341.32	81.789	36.344	15.598	14.7	-18.8	0.	-76.0	-57.1
1964	0.49600	250.00	165.52	1.6288	1.9426	0.	0.	355.94	67.001	35.280	12.022	19.3	-33.8	0.	-81.2	-65.9
1965	0.49500	255.00	143.55	1.6498	2.0000	0.	0.	357.45	54.312	33.264	9.3367	21.2	-43.7	0.	-84.8	-71.9
1966	0.48900	267.00	131.82	1.6105	2.0560	0.	0.	383.77	48.572	30.464	7.2948	27.7	-50.6	0.	-87.3	-76.1
1967	0.45700	243.00	132.48	1.6651	2.1060	0.	0.	410.59	50.185	31.304	7.2028	26.5	-45.5	0.	-87.8	-77.0
1968	0.49800	250.00	145.15	1.7515	2.1530	0.	0.	437.64	62.527	30.576	8.3192	22.9	-41.9	0.	-85.7	-72.8
1969	0.44600	254.00	100.60	1.5533	2.2153	0.	0.	434.45	31.894	29.960	4.2659	42.6	-60.4	0.	-92.7	-85.8
1970	0.56500	262.00	159.90	1.7608	2.2417	0.	0.	424.76	86.734	28.616	11.633	27.3	-39.0	0.	-79.6	-59.3
1971	0.51700	249.00	128.06	1.6986	2.3099	0.	0.	408.69	59.845	28.560	8.3916	36.0	-48.6	0.	-85.4	-70.6
1972	0.49900	242.00	123.17	1.5551	2.3604	0.	0.	415.74	58.893	26.936	7.8739	51.8	-49.1	0.	-85.8	-70.8
1973	0.74200	255.00	178.31	1.6580	2.3971	0.	0.	438.03	130.65	26.152	16.091	44.6	-30.1	0.	-70.2	-38.5
1974	1.0720	266.00	212.86	1.6108	2.4360	0.	0.	474.04	195.35	26.488	21.889	51.2	-25.6	0.	-58.8	-17.4
1975	0.87300	273.00	149.56	1.7035	2.5061	0.	0.	537.77	97.157	26.824	9.6524	46.7	-45.2	0.	-81.9	-64.0

1976	1.1560	262.00	180.07	1.7962	2.5504	0.	0.	589.96	144.58	26.544	12.982	42.0	-31.3	0.	-75.5	-51.1

Model Results for Commodity 5 :

Year	PRICE	ACO	AC	YO	Y	BCO	BC	KCO	KC	LCO	LC	Y-RES	A-RES	B-RES	K-RES	L-RES
1962	0.52100	75.000	125.71	1.4735	1.7245	0.	0.	94.960	63.822	10.560	12.467	17.0	67.6	0.	-32.8	18.1
1963	0.55500	75.000	118.47	1.6380	1.7230	0.	0.	97.520	57.799	10.384	11.002	5.2	58.0	0.	-40.7	6.0
1964	0.57000	75.000	99.071	1.6488	1.7283	0.	0.	101.70	41.571	10.080	7.4377	4.8	32.1	0.	-59.1	-26.2
1965	0.58200	75.000	86.847	1.5076	1.7286	0.	0.	102.13	33.638	9.5040	5.7608	14.7	15.8	0.	-67.1	-39.4
1966	0.60000	75.000	84.135	1.6165	1.7253	0.	0.	109.65	32.773	8.7040	4.8987	6.7	12.2	0.	-70.1	-43.7
1967	0.65000	75.000	113.44	1.6337	1.7009	0.	0.	117.31	59.521	8.9440	8.4943	4.1	51.3	0.	-49.3	-5.0
1968	0.70000	75.000	112.86	1.5168	1.6937	0.	0.	125.04	59.779	8.7360	7.9010	11.7	50.5	0.	-52.2	-9.6
1969	0.82100	75.000	135.00	1.5501	1.6712	0.	0.	124.13	88.656	8.5600	11.768	7.8	80.0	0.	-28.6	37.5
1970	0.77000	75.000	106.22	1.5404	1.6717	0.	0.	121.36	57.679	8.1760	7.6705	8.5	41.6	0.	-52.5	-6.2
1971	0.77100	75.000	101.32	1.5909	1.6784	0.	0.	116.77	55.056	8.1600	7.6473	5.5	35.1	0.	-52.9	-6.3
1972	0.74500	75.000	95.209	1.4266	1.6722	0.	0.	118.78	50.540	7.6960	6.6871	17.2	26.9	0.	-57.5	-13.1
1973	0.91200	74.000	93.002	1.4442	1.6686	0.	0.	125.15	49.899	7.4720	6.0760	15.5	25.7	0.	-60.1	-18.7
1974	1.3140	74.000	111.79	1.5657	1.6486	0.	0.	135.44	73.913	7.5680	8.1805	5.3	51.1	0.	-45.4	8.1
1975	1.1860	74.000	86.339	1.7551	1.6573	0.	0.	153.65	43.425	7.6640	4.2575	-5.6	16.7	0.	-71.7	-44.4
1976	1.1110	74.000	52.389	1.5655	1.6707	0.	0.	168.56	16.053	7.5840	1.4211	6.7	-29.2	0.	-90.5	-81.3

Model Results for Commodity 6 :

Year	PRICE	ACO	AC	YO	Y	BCO	BC	KCO	KC	LCO	LC	Y-RES	A-RES	B-RES	K-RES	L-RES
1962	0.51500	53.000	17.061	3.0902	2.5328	0.	0.	47.480	24.375	5.2800	4.3904	-18.0	-67.8	0.	-48.7	-16.8
1963	0.61500	46.000	19.210	3.5274	2.6048	0.	0.	48.760	33.186	5.1920	5.4797	-26.2	-58.2	0.	-31.9	5.5
1964	0.68700	34.000	17.153	3.6630	2.6801	0.	0.	50.848	28.613	5.0400	4.1953	-26.8	-49.6	0.	-43.7	-16.8
1965	0.63100	40.000	14.000	3.4134	2.7561	0.	0.	51.064	21.002	4.7520	2.7961	-19.3	-65.0	0.	-58.9	-41.2
1966	0.77400	53.000	17.566	3.5784	2.8275	0.	0.	54.824	36.102	4.3520	3.9956	-21.0	-66.9	0.	-34.1	-8.2
1967	0.88500	57.000	26.517	3.0161	2.8940	0.	0.	58.656	85.102	4.4720	8.5984	-4.0	-53.5	0.	45.1	92.3
1968	0.84800	54.000	22.603	3.2747	2.9704	0.	0.	62.520	65.027	4.3680	5.8401	-9.3	-58.1	0.	4.0	33.7
1969	0.88100	54.000	22.396	3.6939	3.0434	0.	0.	62.064	67.877	4.2800	5.8974	-17.6	-58.5	0.	9.4	37.8
1970	0.82000	44.000	18.954	4.0911	3.1174	0.	0.	60.680	52.297	4.0880	4.3996	-23.8	-56.9	0.	-13.8	7.6
1971	0.81500	39.000	18.768	4.6765	3.1937	0.	0.	58.384	54.559	4.0800	4.6484	-31.7	-51.9	0.	-6.6	13.9
1972	0.81200	42.000	20.551	3.6208	3.2651	0.	0.	59.392	69.550	3.8480	5.4896	-9.8	-51.1	0.	17.1	42.7
1973	0.99000	49.000	18.384	4.2813	3.3409	0.	0.	62.576	58.721	3.7360	4.1599	-22.0	-62.5	0.	-6.2	11.3
1974	1.1200	50.000	15.537	4.1886	3.4161	0.	0.	67.720	43.627	3.7840	2.7468	-18.4	-68.9	0.	-35.6	-27.4
1975	1.2680	42.000	19.881	4.5608	3.4865	0.	0.	76.824	71.602	3.8320	3.9141	-23.6	-52.7	0.	-6.8	2.1
1976	1.3510	38.000	16.335	3.9132	3.5632	0.	0.	84.280	49.250	3.7920	2.3878	-8.9	-57.0	0.	-41.6	-37.0

Model Results for Commodity 7 :

Year	PRICE	ACO	AC	YO	Y	BCO	BC	KCO	KC	LCO	LC	Y-RES	A-RES	B-RES	K-RES	L-RES
1962	0.	4966.0	4784.7	1.0624	1.0624	0.	0.	296.75	348.75	26.400	30.138	0.	-3.7	0.	17.5	14.2
1963	0.	5040.0	4727.4	1.1232	1.1232	0.	0.	304.75	348.38	25.960	28.671	0.	-6.2	0.	14.3	10.4
1964	0.	5114.0	4606.1	1.1736	1.1736	0.	0.	317.80	354.87	25.200	26.840	0.	-9.9	0.	11.7	6.5
1965	0.	5188.0	4748.3	1.1602	1.1602	0.	0.	319.15	377.61	23.760	26.743	0.	-8.5	0.	18.3	12.6
1966	0.	5261.0	4870.2	1.1448	1.1448	0.	0.	342.65	437.19	21.760	26.449	0.	-7.4	0.	27.6	21.5
1967	0.	5097.0	4988.1	1.1881	1.1881	0.	0.	366.60	459.81	22.360	26.006	0.	-2.1	0.	25.4	16.3
1968	0.	4847.0	5200.8	1.2278	1.2278	0.	0.	390.75	509.06	21.840	26.123	0.	7.3	0.	30.3	19.6
1969	0.	4855.0	5296.5	1.2556	1.2556	0.	0.	387.90	508.71	21.400	25.698	0.	9.1	0.	31.1	20.1
1970	0.	5191.0	5571.2	1.2514	1.2514	0.	0.	379.25	528.04	20.440	26.206	0.	7.3	0.	39.2	28.2
1971	0.	4821.0	5112.0	1.4480	1.4480	0.	0.	364.90	454.22	20.400	23.099	0.	6.0	0.	24.5	13.2
1972	0.	4984.0	5347.3	1.4852	1.4852	0.	0.	371.20	491.90	19.240	23.390	0.	7.3	0.	32.5	21.6
1973	0.	5140.0	5096.4	1.5757	1.5757	0.	0.	391.10	497.02	18.680	21.359	0.	-0.8	0.	27.1	14.3

1974	0.	5213.0	4850.0	1.6547	1.6547	0.	0.	423.25	504.73	18.920	19.370	0.	-7.0	0.	19.3	-2.4
1975	0.	5206.0	4973.1	1.6667	1.6667	0.	0.	480.15	569.07	19.160	19.017	0.	-4.5	0.	18.5	-0.7
1976	0.	5665.0	5407.6	1.4837	1.4837	0.	0.	526.75	671.16	18.960	19.916	0.	-4.5	0.	27.4	5.0

Model Results for Livstock Category 1 :

Year	PRICE	NO	N	YO	Y	BCO	BC	KCO	KC	LCO	LC	Y-RES	A-RES	B-RES	K-RES	L-RES
1962	0.61100	464.00	505.44	1.00000	1.00000	0.	0.	474.80	525.56	46.200	50.798	0.	8.9	0.	10.7	10.0
1963	0.63400	462.00	546.66	1.00000	1.00000	0.	0.	487.60	576.20	45.430	52.425	0.	18.3	0.	18.2	15.4
1964	0.60300	500.00	547.17	1.00000	1.00000	0.	0.	508.48	588.78	44.100	48.696	0.	9.4	0.	15.8	10.4
1965	0.58900	474.00	528.89	1.00000	1.00000	0.	0.	510.64	574.38	41.580	44.026	0.	11.6	0.	12.5	5.9
1966	0.72300	478.00	563.07	1.00000	1.00000	0.	0.	548.24	628.27	38.080	40.742	0.	17.8	0.	14.6	7.0
1967	0.78100	563.00	645.11	1.00000	1.00000	0.	0.	586.56	741.91	39.130	44.576	0.	14.6	0.	26.5	13.9
1968	0.66500	664.00	658.71	1.00000	1.00000	0.	0.	625.20	771.78	38.220	41.722	0.	-0.8	0.	23.4	9.2
1969	0.66800	628.00	673.20	1.00000	1.00000	0.	0.	620.64	788.29	37.450	41.627	0.	7.2	0.	27.0	11.2
1970	0.77100	641.00	729.33	1.00000	1.00000	0.	0.	606.80	851.96	35.770	43.886	0.	13.8	0.	40.4	22.7
1971	0.70100	733.00	743.95	1.00000	1.00000	0.	0.	583.84	866.85	35.700	45.460	0.	1.5	0.	48.5	27.3
1972	0.55600	656.00	700.10	1.00000	1.00000	0.	0.	593.92	812.28	33.670	39.596	0.	6.7	0.	36.8	17.6
1973	0.80900	641.00	682.89	1.00000	1.00000	0.	0.	625.76	809.06	32.690	35.455	0.	6.5	0.	29.3	8.5
1974	1.1840	634.00	729.45	1.00000	1.00000	0.	0.	677.20	903.29	33.110	35.182	0.	15.1	0.	33.4	6.3
1975	1.0900	541.00	729.78	1.00000	1.00000	0.	0.	768.24	929.95	33.530	31.407	0.	34.9	0.	21.0	-6.3
1976	1.4700	531.00	836.86	1.00000	1.00000	0.	0.	842.80	1095.4	33.180	32.730	0.	57.6	0.	30.0	-1.4

Model Results for Livstock Category 2 :

Year	PRICE	NO	N	YO	Y	BCO	BC	KCO	KC	LCO	LC	Y-RES	A-RES	B-RES	K-RES	L-RES
1962	4.1650	72.000	75.195	1.00000	1.00000	0.	0.	118.70	115.23	19.800	19.216	0.	4.4	0.	-2.9	-2.9
1963	4.3310	74.000	73.576	1.00000	1.00000	0.	0.	121.90	120.58	19.470	19.092	0.	6.2	0.	-1.1	-1.9
1964	4.3880	79.000	81.767	1.00000	1.00000	0.	0.	127.12	130.12	18.900	18.882	0.	3.5	0.	2.4	-0.1
1965	4.2980	82.000	84.498	1.00000	1.00000	0.	0.	127.66	137.81	17.820	18.677	0.	3.0	0.	8.0	4.8
1966	4.4450	87.000	87.112	1.00000	1.00000	0.	0.	137.06	159.53	16.320	18.425	0.	0.1	0.	16.4	12.9
1967	5.0250	90.000	91.302	1.00000	1.00000	0.	0.	146.64	168.39	16.770	18.142	0.	1.4	0.	14.8	8.2
1968	4.2650	90.000	93.626	1.00000	1.00000	0.	0.	156.30	180.03	16.380	17.564	0.	4.0	0.	15.2	7.2
1969	4.4270	98.000	96.454	1.00000	1.00000	0.	0.	155.16	179.39	16.050	17.198	0.	-1.6	0.	15.6	7.2
1970	4.7750	106.00	99.888	1.00000	1.00000	0.	0.	151.70	181.43	15.330	17.061	0.	-5.8	0.	19.6	11.3
1971	4.1100	104.00	101.66	1.00000	1.00000	0.	0.	145.96	170.69	15.300	16.425	0.	-2.2	0.	16.9	7.4
1972	3.8950	104.00	103.04	1.00000	1.00000	0.	0.	148.48	176.36	14.430	15.849	0.	-0.9	0.	18.8	9.8
1973	4.4340	108.00	103.28	1.00000	1.00000	0.	0.	156.44	183.97	14.010	14.927	0.	-4.4	0.	17.6	6.5
1974	6.7790	108.00	106.00	1.00000	1.00000	0.	0.	169.30	197.70	14.190	14.312	0.	-1.9	0.	16.8	0.9
1975	7.3110	99.000	109.67	1.00000	1.00000	0.	0.	192.06	219.60	14.370	13.834	0.	10.8	0.	14.3	-3.7
1976	7.4590	105.00	112.32	1.00000	1.00000	0.	0.	210.70	237.90	14.220	13.301	0.	7.0	0.	12.9	-6.5

Model Results for Livstock Category 3 :

Year	PRICE	NO	N	YO	Y	BCO	BC	KCO	KC	LCO	LC	Y-RES	A-RES	B-RES	K-RES	L-RES
1962	0.06600	2906.1	2379.5	2.8719	2.8719	0.	0.	1721.2	2040.8	99.000	145.83	0.	-0.9	0.	18.6	47.3
1963	0.07100	2840.9	2796.4	2.9459	2.9459	0.	0.	1767.6	2064.8	97.350	137.38	0.	-1.6	0.	16.8	41.1
1964	0.07100	2807.1	2667.3	2.9927	2.9927	0.	0.	1843.2	2118.5	94.500	126.84	0.	-5.0	0.	14.9	34.2
1965	0.07400	2753.8	2525.4	3.0271	3.0271	0.	0.	1851.1	2128.3	89.100	116.98	0.	-8.3	0.	15.0	31.3
1966	0.07100	2648.3	2336.4	3.1511	3.1511	0.	0.	1987.4	2291.6	81.600	105.64	0.	-11.8	0.	15.3	29.5
1967	0.08500	2549.8	2249.6	3.2423	3.2423	0.	0.	2126.3	2292.4	83.850	97.138	0.	-11.8	0.	7.8	15.8
1968	0.09900	2474.9	2192.6	3.3682	3.3682	0.	0.	2266.4	2430.4	81.900	91.994	0.	-11.4	0.	7.2	12.3
1969	0.10300	2427.0	2161.0	3.5002	3.5002	0.	0.	2249.8	2405.6	80.250	88.365	0.	-11.0	0.	6.9	10.1
1970	0.10200	2355.3	2113.4	3.5300	3.5300	0.	0.	2199.6	2378.1	76.650	84.710	0.	-10.3	0.	8.1	10.5
1971	0.10100	2237.6	2072.5	3.5449	3.5449	0.	0.	2116.4	2228.9	76.500	80.415	0.	-7.4	0.	5.3	5.1

1972	0.10900	2185.5	2092.9	3.6724	3.6724	0.	0.	2153.0	2412.0	72.150	80.515	0.	-4.2	0.	12.0	-11.6
1973	0.12100	2115.4	1999.8	3.6244	3.6244	0.	0.	2268.4	2490.3	70.050	74.435	0.	-5.5	0.	9.8	6.3
1974	0.14100	2059.8	1812.0	3.7058	3.7058	0.	0.	2454.9	2398.0	70.950	63.490	0.	-12.0	0.	-2.3	-10.5
1975	0.18300	2035.9	1805.6	3.8072	3.8072	0.	0.	2784.9	2671.1	71.850	61.150	0.	-11.3	0.	-4.1	-14.9
1976	0.22900	1976.0	1806.2	3.8932	3.8932	0.	0.	3055.1	2950.0	71.100	59.613	0.	-8.6	0.	-3.4	-16.2

Model Results for Livstock Category 4 :

Year	PRICE	NO	N	YO	Y	BCO	BC	KCO	KC	LCO	LC	Y-RES	A-RES	B-RES	K-RES	L-RES
1962	0.88200	5276.0	5083.4	0.13533	0.13533	0.	0.	1305.7	1288.5	158.40	149.41	0.	-3.7	0.	-1.3	-5.7
1963	0.99100	5661.0	5309.9	0.13284	0.13284	0.	0.	1340.9	1308.3	155.76	147.98	0.	-6.2	0.	-2.4	-5.0
1964	0.92300	6002.0	5405.9	0.13862	0.13862	0.	0.	1398.3	1336.0	151.20	142.17	0.	-9.9	0.	-4.5	-6.0
1965	0.88600	6019.0	5508.8	0.15335	0.15335	0.	0.	1404.3	1345.5	142.56	137.18	0.	-8.5	0.	-4.2	-3.8
1966	0.92400	6023.0	5575.6	0.15208	0.15208	0.	0.	1507.7	1461.0	130.56	130.13	0.	-7.4	0.	-3.1	-0.3
1967	0.99400	6056.0	5926.6	0.14894	0.14894	0.	0.	1613.0	1536.3	134.16	130.76	0.	-2.1	0.	-4.8	-2.5
1968	1.0680	5951.0	6385.4	0.15964	0.15964	0.	0.	1719.3	1686.3	131.04	133.06	0.	7.3	0.	-1.9	1.5
1969	1.0330	6096.0	6650.3	0.14764	0.14764	0.	0.	1706.8	1662.6	128.40	131.88	0.	9.1	0.	-2.6	2.7
1970	1.1440	6496.0	6971.8	0.13962	0.13962	0.	0.	1668.7	1655.9	122.64	131.72	0.	7.3	0.	-0.8	7.4
1971	1.1780	6981.0	7402.3	0.13637	0.13637	0.	0.	1605.6	1608.9	122.40	133.80	0.	6.0	0.	0.2	9.3
1972	1.2550	7402.0	7941.6	0.12915	0.12915	0.	0.	1633.3	1717.3	115.44	136.16	0.	7.3	0.	5.1	18.0
1973	1.3570	8099.0	8030.4	0.11779	0.11779	0.	0.	1720.8	1774.5	112.08	129.60	0.	-0.8	0.	3.1	15.6
1974	1.7310	8626.0	8025.3	0.11593	0.11593	0.	0.	1862.3	1828.8	113.52	121.53	0.	-7.0	0.	-1.8	7.1
1975	1.8430	8677.0	8288.8	0.12850	0.12850	0.	0.	2112.7	1994.3	114.96	117.50	0.	-4.5	0.	-5.6	2.2
1976	1.7240	8405.0	8023.1	0.14337	0.14337	0.	0.	2317.7	1999.0	113.76	106.45	0.	-4.5	0.	-13.8	-6.4