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A MODEL TO DETERMINE THE IMPACT OF IMPROVED AGRICULTURAL EFFICIENCY IN MANITOBA

by

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ABSTRACT

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One of the major objectives of agricultural policy in Canada over time has been the efficient use of resources in the agriculture industry. Efficient use of resources among other things depends on the size of the firm. There are several measures of farm size e.g. number of acres, gross value of production, number of workers, net returns etc. A measure is usually selected by how well it serves as a base for the particular kinds of size comparison to be made. For example, acreage may be a useful measure when one is concerned with crop production, while it may be a poor measure for poultry operations. Like census reports, farm size was measured in terms of acres. The small sized firms tend to be less efficient because they have to bear certain fixed costs with a small quantity of output. The large sized farms may not have the minimum average total cost because of problems of co-ordination, efficient decision making and the like. Economies of scale which are associated with an increase in farm size up to certain limits in agriculture have resulted in an increase in the average farm size and a reduction in the total number of farms. The large efficient farms emerging in the agriculture industry

have implications for income and employment. The general objectives of the study were to determine the spatial optimal organization of crop production in Manitoba, given efficient sized farms, and to estimate the income and employment and the distribution of both with this organization. To deal with these objectives, an efficient farm size was determined by using the survivor approach. It was assumed that the farms so determined were of efficient size for the present study. Then a multiregional linear programming model was developed in order to determine the optimal organization. Two soil types, all the crop districts of Manitoba and nine crops were included in the model. The crops were wheat, oats, barley, flaxseed, rapeseed, rye, sunflowers, potatoes and sugarbeets. Restraints were specified with regard to the availability of land of each soil type, maximum and minimum production of each crop, and the minimum amount of metabolized energy required at the crop district level. Minimum demand constraints were also placed on each commodity at the provincial level. The optimum organization for crop production was defined as that combination of activities which maximized net income.

The main findings of the study with 1974-75 prices were:

1. Total area allocated to crops under optimal solution was higher by 21 percent as compared with actual acreage in 1976. With the exception of wheat, potatoes, and sugarbeets, the area occupied by other crops was higher in the optimal solution than the actual area. At the regional level, Central and South West regions experienced an increase in the total cropped area, while a decrease was observed in the Eastern and North West regions in the optimal acreage as compared with the actual one. This was the result of higher net income per acre associated with

most of the crops in the Central and South West regions as compared to other regions. From this one can conclude that efficient organization would lead to not only an increase in the cropped area, but would also substantially change the pattern of land use in Manitoba.

2. For the province, optimal levels of production of all crops were higher than the actual and/or normal levels of production in 1976 with the exception of wheat and sugarbeets whose optimum levels were lower than the actual levels. "Normal" is used to mean the trend level of production. The Central and South West regions made maximum contribution towards the total optimal production of each crop. Collectively both the regions shared 60.03 percent to 91.48 percent of the total provincial production of different crops. This was the result of higher net income per acre associated with most of the crops in these regions. Eastern and Interlake regions were the least important in terms of contribution toward the total production. Central and South West regions which were already sharing a high proportion of the total production of each crop, would contribute relatively more towards the output of different crops with the optimal organization of agriculture.

3. The total employment with optimal organization of crop production totalled 8,964 man years. When the labor requirements for livestock and poultry were also taken into account, the total employment amounted to 21,118 man years which was substantially less than the projected labor requirement of 42,000 for agriculture by the Department of Industry and Commerce. The optimal employment was more or less the same as the actual one. However, Central and South West regions contributed considerably more, while the other regions less towards total employment

with optimal organization than with the actual one. This leads to the conclusion that Central and South West regions would become more important in terms of their contribution to total employment, while the share of other regions would decline.

4. Net income from optimal crop production came to 690 million dollars which was higher by 50 percent than the actual net income. The higher level of net income resulting from an optimal organization of crop production on efficient sized farms suggests an adjustment of farms towards optimum size.

The contribution of the Interlake, Eastern and North West regions was lower, while that of Central and South West regions was higher towards the total net income with the optimal organization of crop production as compared to the actual one. Thus one could expect that Central and South West regions would experience an increase and other regions a decrease in sharing the total net income with an efficient organization of crop production.

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TABLE OF CONTENTS

LIST OF TABLES

TABLE PAGE

TABLE PAGE

TABLE PAGE

APPENDIX TABLES

TABLE PAGE

LIST OF FIGURES

CHAPTER I

INTRODUCTION

STATEMENT OF THE PROBLEM

After the Second World War, Canadian economic policy had five goals: full employment, a high rate of economic growth, reasonable stability of prices, maintenance of a viable balance of payments and an equitable distribution of income.[1] An implicit general goal for agriculture was in the words of Anderson:

> Agriculture should be an efficient industry in all respects, including the production of various products and the location of the industry, adjusting effectively to the time of domestic and export demands for its products, and meeting fully the competition of other industries for labor, capital and other resources needed in agriculture; so that its earnings would be equivalent to those set by the general level prevailing in the economy.[2]

This objective was consistent with the goals of national policy. It aimed at creating an agricultural industry that would compete on an equal basis for resources and for consumer purchasing power, and would share in the results of economic growth.[3] It would also improve the competitive position of Canadian agriculture by providing cheap food in the international market.

The four principles of Guidelines for the Seventies set by the Province of Manitoba (maximizing the general well being of Manitobans,

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[1] W.M. Drummond, W.J. Anderson and T.C. Kerr, A Review of Agricultural Policy in Canada, Agricultural Economics Research Council of Canada, June 1966, p. 67.

[2] W.J. Anderson, "Agricultural Policy in Prespective", Agricultural Economics Research Council of Canada, 1967, p. 10.

[3] Ibid., p. 10.

greater equality of the human condition, the stay option and widening participation) implied specific objectives for agriculture explicitly.[4] These included:

1. Expanding agricultural output to raise total income from agriculture.

2. Stabilizing net farm income through diversifying agricultural production and through effective action in the marketing of farm products and purchases of farm supplies.

3. Enhancing the economic viability of low and middle income producers, through programs geared specifically towards providing the smaller and medium sized farmers with financial and management assistance.[5]

The stay option principle of Guidelines for the Seventies emphasized the discouragement of migration from rural to urban areas. Guidelines also emphasized a more equitable distribution of the benefits of development. In brief, one can identify the goals for agriculture over time as higher net income per capita, resource efficiency, regional stability of employment and greater equality in income distribution. In order to fulfill these objectives various programs were, or are going on, in Manitoba. For example, research, extension, education[6] and manpower training[7]

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[4]The Province of Manitoba, Guidelines for the Seventies, Introduction and Economic Analysis, March 1973, pp. 83-84.

[5]Ibid., p. 85.

[6]Drummond, Anderson and Kerr, op. cit., pp. 79-80.

[7]Ibid., pp. 76-77.

emphasized the resource efficiency goal of agriculture. The Farm Diversification Program,[8] Small Farm Development Program[9] and Land Lease Program[10] were designed to increase the viability of low income farms, and thus emphasized the greater equality of income goal in a given region. Greater equality of income among different regions was strengthened through the introduction of ARDA[11] (Agricultural Rural Development Act). The Farm Diversification Program [12] and Western Grain Stabilization Program[13] were designed to improve and stabilize the income of farmers. An effort was made to fulfill the objective of stable employment indirectly by enabling farmers to make a good living from agriculture by programs which emphasized income improvement i.e. higher incomes and more stable incomes.

Despite all the different programs carried out in the past and at present, agriculture in Manitoba has undergone a number of changes. There has been a shift from the employment of large amounts of labor and small amounts of capital to the large inputs of capital and small inputs of labor. The farm labor force in the prairie provinces decreased by

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[8] ARDA Manitoba/Canada, Agricultural and Rural Development Act, Description and Progress Report, 1972-73, p. 11.

[9] Agriculture Canada, Policies and Programs for Agriculture, Western Provinces, 1976, M 55, p. 2.

[10] Ibid., M 17, p. 6.

[11] See Agricultural Rural Development Act (ARDA), 1966-67, C 11, S 2, Chapter A-4 and Jack Giles, ARDA in Manitoba, Province of Manitoba, Jan. 1968, p. 6.

[12] ARDA Manitoba/Canada, op. cit., p. 11.

[13] H.W. Leggett, "Causes, Costs and Cares of Instability in Canadian Agriculture" in New Developments in Agricultural Stabilization: Proceedings of 1976 Workshop of Canadian Agricultural Economic Society, March 1976, p.41.

27 percent over the time period 1957-74,[14] while the total farm cash inputs, excluding hired labor, increased by 71 percent during the same period.[15] Associated with these changes in resource use, a large change also occurred in the structure of the farm industry. The total number of farms was 58,024 in 1941 but declined by 45 percent, to 32,104 in 1976. Average farm size which was 291 acres in 1941 increased by 104 percent, to 593 acres in 1976, (Table 1). Different studies conducted also indicated that adjustment in farms is characterized by fewer and larger farms in Canada and U.S.A..[16] These larger farms are substituting capital for labor because of the rising costs of labor relative to capital. Farm firms are becoming larger and fewer due to the fact that there exist important differences in efficiency between farms of different sizes, as is emphasized by Quance and Tweeten

> .....Large farms on the average are currently more efficient than small farms. Put in another way, the good big farmer can outcompete the good little farmer. The difference between the efficiency of large farms and small farms is widening. The opportunity cost or economic penalty for operating a small farm with technology of an earlier decade is rising. The magnitude of adjustments in scale of operations necessary to produce efficiently is accelerating.[17]

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[14]Calculated from Statistics Canada, The Labor Force, March 1975, p.67

[15]Price indexes were applied in order to eliminate the effect of increase in expenditure due to prices. Calculated by taking data from Manitoba, Department of Agriculture, Manitoba Agriculture Yearbook 1975 and 1970.

[16]See James A. MacMillan, F.L. Tung and John R. Tulloch, "Migration Analysis and Farm Projection Model: A synthesis." American Journal of Agricultural Economics, Vol. 56, No. 2, May 1974, pp. 292-299 and R.F. Daly, J.A. Dempsey and C.W. Cobb, "Farm Numbers and Sizes in Future" in Size, Structure and Future of Farms, eds. A. Gordon Ball and Earl O. Heady, Ames Iowa State University Press, 1972, pp. 314-332.

[17]Leroy Quance and Luther G. Tweeten, "Policies 1930-1970" in Size, Structure and Future of Farms, eds. A. Gordon Ball and Earl O. Heady, Ames, Iowa State University Press, 1972, p. 36.

TABLE 1

NUMBER OF FARMS AND AVERAGE FARM AREA IN DIFFERENT YEARS

YEAR	NUMBER OF FARMS	AVERAGE FARM SIZE (Acres)
1941	58,024	291
1951	52,383	338
1961	43,306	420
1966	39,747	480
1971	34,981	543
1976	32,104	593

Source, Manitoba Department of Agriculture, _Manitoba Agriculture Yearbook_, Queen's Printer, Winnipeg, 1976, p. 96.

The importance of the larger farms which are efficient is well expressed by Ball and Heady. According to them:

> ....This group represents the growth point of our expanding agriculture. That growth point is at the top, just as it is on the corn plant. This then is the most critical portion of our agriculture, for it is these farmers and farms that are extending into "unchartered water". It is these that set the pace and determine the time for changing directions or new surges forward. It is these that are creating, exploring and extending new dimensions. Farms in other size groups below this, but still among those that are growing and expanding over time, are but followers of these growth points.[18]

The larger farms are in an advantageous position because the average fixed cost per unit of output declines as the fixed costs are spread over a larger output, i.e. there are economies of size. The small farm firms are in a disadvantageous position because they have to bear certain unavoidable costs with a small quantity of output. Theoretically, one can also consider the idea of diseconomies of size, which would occur once a certain size is reached, because of problems concerning co-ordination, efficient decision making and the like. Putting the idea of economies and diseconomies together, there are theoretical reasons to believe that below a certain size, farm firms are too small to give the lowest average cost per unit of output, while above another point in the size scale, farm firms are too large and average cost per unit of output could be decreased if they were smaller. Economic theory suggests that the firms adjust towards their efficient size (i.e. the size at which the average cost of producing output is minimized). In the long run, only firms of optimum size which are using the most efficient methods of production can compete. Firms which are not employing the efficient methods of production

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[18] A. Gordon Ball and Earl O. Heady, Size, Structure and Future of Farms, Ames, Iowa State University Press, 1972, p. 53.

and are not of optimum size, are eliminated because they fail to supply the product at the price where the output could be produced at the minimum average cost. Firms of optimum size must use the efficient methods of production in order to produce the output at the lowest longrun average cost.

These optimum sized farms, in which form theory suggests the agricultural industry has to emerge finally have implications for income, employment and the distribution of both. Farm size is related to income in two ways.

1. The amount of income is a function of size of the farm. Even when there are no economies or diseconomies for farms of different sizes, small farms have lower income than larger farms, and

2. The amount of income relative to the quantity of resources used depends on the nature of cost advantages or disadvantages of farms of different sizes.

If there are economies of scale, then doubling the use of all resources will increase the net income more than twice. Thus, large farms which realize economies of scale have higher income than smaller farms.

Farm size is related to labor employment in the sense that the labor requirement per unit of output is inversely related to the size of the farm. Thus an efficient agriculture industry based on large farms would lead to the reduction in total employment.

Given an optimum size, production of different crops is influenced by two types of factors for different regions:

1. There are factors which affect the prices received by farmers for different products; they include market location, transportation and handling costs. These factors cause costs to increase with the increase in distance, areas-near market usuallyenjoy an element of comparative ad-

vantage over areas located further away. This means that areas located closer to market receive a higher net price than the areas at greater distance.

2. There are factors which affect the per unit cost of production of different products; climate, soil and topography determine yields and hence cost per bushel. Due to these factors which influence prices and costs, farms in different areas have advantages in various types of production. Under the conditions of real life, a particular area may have an absolute advantage for the production of most or all crops over other areas, but it may lack sufficient productive capacity to meet the needs of other areas of all crops. In such a case it would concentrate in the production of those crops for which it had the highest comparative advantage and the other area would concentrate in the production of those products in which it had the least comparative disadvantage. The comparative advantage positions determine the optimum organization of crops in different regions which in turn influence the income and employment distribution among regions. Spatial optimum organization of agriculture on the efficient sized farms raises a number of questions. Some of these questions which are of particular interest to the policy-makers are:

1. What would agriculture be like if agriculture is organized according to the technical and economic efficiency criteria i.e. when optimum sized farms are employing the efficient methods of production while allocating resources to various crops in order to maximize their profits?

2. What would be the potential optimum organization and income from crop production if all farms were of efficient size and were using the most efficient methods of production currently known?

3. What would be the total employment with the optimal organization in agriculture?

4. What would be the income distribution associated with the optimal organization of crops among regions?

Answers to the above questions are needed to determine how large the potential adjustment and distributional problems are so that policy needs can be anticipated. This study is designed to provide knowledge for a better assessment of production and adjustment potentials that could occur over future decades. This can stimulate public policies which should be followed in order to cope with tomorrow's needs.

OBJECTIVES OF THE STUDY

The general objective of this study is to determine the implications of efficient agricultural production in Manitoba based on the current technology. Specifically the objectives are:

1. To estimate the profit maximizing organization of crop production that would result on the basis of production techniques employed by currently economically efficient Manitoba farms.

2. To estimate the level of aggregate crop production that would result from an efficient agriculture.

3. To make a comparison of the optimal locational distribution of acreage and production with the actual and/or normal acreage and production where ever possible.

4. To determine income and its distribution among regions that would result from the efficient Manitoba agriculture.

5. To estimate the total amount of labor required with the optimal crop organization for Manitoba.

SCOPE OF THE PRESENT STUDY

The present study is concerned with the determination of the competitive position of different regions of Manitoba in producing crops. Efficient regional cropping patterns on the optimum sized farms are estimated with the "efficient" rather than the "average" methods of production given the provincial demand for each commodity. All the 14 crop districts, two soil types and nine crops (i.e. wheat, oats, barley, flaxseed, rapeseed, rye, sunflowers, potatoes and sugarbeets) are considered. Production of each crop in each crop district is constrained by the maximum and minimum production restraints. These restraints are based on historical production levels. The range of production represents the maximum level of adjustment allowed to farmers producing each commodity. Restraints are also placed about the availability of land of each soil type at the crop district level. The analysis is incomplete in the sense that it is concerned only with the crop production sector, while the livestock sector is ignored. However, livestock feed requirements at the crop district level are included.

The model used in this study to determine the optimal production pattern for Manitoba is a linear programming partial equilibrium model. The model allows interregional competition and determine the optimal organization for crop production on efficient sized farms for the given level of prices of commodities and various types of constraints.

ORGANIZATION OF THE REMAINDER OF THE THESIS

Chapter II reviews the studies relevant to this study. Chapter III discusses the theory of competitive farm firm and various approaches to general equilibrium analysis. Chapter IV deals with the determination of efficient farm size, assumptions and the specific model used in this study. The data used in the model are also discussed. The results produced through the application of the model are presented in Chapter V. A summary of results and conclusions are discussed in Chapter VI. Chapter VI also deals with the policy implications and limitations of the study and suggestions for further research.

CHAPTER II

REVIEW OF PREVIOUS STUDIES

A number of studies have been done to determine the optimal spatial organization of agriculture through the efficient use of agricultural resources. This chapter reviews the studies relevant to this study. In all the studies reviewed, a linear programming model of inter-regional competition in agriculture was used to determine the optimal production organization. The later studies used considerably more detailed models than the models used by earlier studies. In some of the studies only minor modifications were made to the earlier studies in order to determine the optimal production under changed conditions.

The first study reviewed was conducted by Egbert and Heady.[19] They determined the optimum production location for wheat and feed grains in 104 producing regions of U.S.A.. These regions, made by dividing the portion of the United States where wheat and feed grains were mainly produced, accounted for 90% of all feed grains and wheat produced in the United States. Annual production restraints were specified at the aggregate demand level for wheat and feed grains. These demand restraints were based on the normal per unit requirements of the human or livestock populations, or both, and the actual net exports in 1954. Restraints were placed on the acreage available for production of grains in each region

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[19] Elvin C. Egbert and Earl O. Heady, Regional Adjustment in Grain Production, A Linear Programming Analysis; Iowa Agri. and Home Economics Experiment Station, Iowa State College, Ames, Iowa, Technical Bulletin 1241, June 1961.

and the quantities of wheat and feed grains required for consumption in 1954. For the given level of production restraints, product prices and production costs, the optimum location of production among regions was determined. Analysis was carried out on the assumption that technical co-efficients were equal to the average of the region and were constant. Transportation costs were ignored on the assumption that commodities could be shipped from producing areas to consuming areas at no cost. Five models (A to E) were included in this study. E was a maximum profit model, while A to D were minimum cost models. For model A, B, C and E production activities were food wheat, feed wheat and feed grain rotation, for D, they were food wheat, feed wheat, corn, oats, barley and grain sorghum. Land-rent was included in costs in model B, while it was not included in the other models.

Heady and Whittlesey[20] expanded the above mentioned model by including 31 consuming regions and increasing the number of producing regions to 144. The number of producing areas was increased for two reasons:

1. the addition of soybeans and cotton, which made it necessary to include areas of U.S. that were not included in the Egbert and Heady study, and

2. some of Egbert and Heady's 104 regions were further divided so that each producing region would be entirely within the boundary of a single consuming region.

Requirement levels of wheat, feed grains and oil meals were specified for each of the 31 consuming regions. A national demand for

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[20]Earl O. Heady and Norman Whittlesey, "Land Qualities and Crop Production Capacity" in Spatial Sector Programming Models in Agriculture, eds. Earl O. Heady and U.K. Srivastava, Iowa State University Press, 1975, pp. 56-101.

cotton was specified. Transportation activities were introduced in order to allow the movement of wheat, feed grains and oil meals among consuming regions. Transport cost was assumed to be zero where a crop activity contributing to the demand of the consuming region was produced within that same region. The optimum production pattern was defined for three models as that pattern which would minimize the total cost of satisfying demand requirements. In model I, it was assumed that wheat feed grain transfer activities had zero cost. In model II, feed grain transfer activities had non-zero cost. Model III differed significantly from the above two models and from the Egbert and Heady study on the basis that in each producing area, three soil categories were considered and per acre yields and costs for each crop and each soil were determined. This resulted in increasing the total crop land restraints and crop producing activities by three times as compared to model I. This study like the Egbert and Heady study, used the technical coefficients of average producing units rather than those of larger efficient farms. Technical coefficients of average producing units were used in determining efficient organization because of computer capacity limitations and lack of data.

Heady and Skold[21] developed a model similar to the preceding one except that the model used the projected data for 1975 for determining the optimal organization whereas Whittlesey and Heady used 1965 as a base year. This model also included soybean rotation activities.

All the above studies considered only crop production, while

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[21] Earl O. Heady and Melvin O. Skold, "Capacity Interregional Adjustment and Land Use" in Spatial Sector Programming Models in Agriculture, eds. Earl O. Heady and U.K. Srivastava, Iowa State University Press, 1975, pp. 120-155.

the livestock sector was taken as exogenous, i.e. livestock production was taken as given and the total crop requirements were defined such that they also included the feed requirement of the livestock produced in that region. Brokken and Heady[22] developed a model for determining the optimum organization of crops and livestock which would minimize total production and transportation cost. Crop production activities were increased to include cotton, wheat, feed grain rotations, feed grain soybean rotations, feed grain silage rotations, hay, hay silage rotations and wild hay. Twelve livestock producing activities were included. In this model 157 crop producing areas and 20 livestock producing regions were specified. Each of the livestock producing regions contained one or more of the crop producing areas. Unlike the previously described models, the requirements of crop products included only the requirements for food, industrial use and for exports. Crop products were transferred to the feed supply row and the feed required in each livestock producing region was obtained from this supply. Livestock production in each region was limited by pasture constraints and by livestock capacity constraints. The capacity constraints were defined as the maximum number of each type of livestock in each region. The production of intensive crops (cotton, wheat, feed grains, soybean and silage) in each area was limited to the amount of land used for these crops in the past, while hay could be produced both on the land used for hay in the past and on any land available for but not used for intensive crop production.

In all the above studies, the farms of each producing region were assumed to be representable by an "average" producing unit. The optimum

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[22] Ray F. Brokken and Earl O. Heady, "Adjustment in Crop and Livestock Production" in Spatial Sector Programming Models in Agriculture, eds. Earl O. Heady and U.K. Srivastava, Iowa State University Press, 1975, pp. 156-200.

combination of enterprises that was determined for an area was assumed to be optimal for all farms in that area. But farms of different sizes have different input-output coefficients and different amounts and qualities of resources available. Even the farms producing agriculture crops more efficiently as compared to others in the same size have different input-output coefficients. To partially account for the differences in production efficiencies existing between farms located in the same area, farm size was considered explicitly in studies conducted by Eyvindson,[23] Craddock[24] and Framingham et al. [25]

The largest linear programming model for the U.S. was developed by Eyvindson.[26] His model was similar to the Brokken and Heady model in several respects. He used the same 157 producing areas, the same consuming regions (except that one region was further divided into two regions) and the same crop and livestock activities. Both were concerned with determination of the optimal production pattern which would minimize total production and transportation cost. This study, however,

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[23]Roger K. Eyvindson, " A Model of Interregional Competition in Agriculture Incorporating Consuming Regions, Producing Areas, Farm Size Group and Land Classes". Unpublished Ph.D. thesis, Iowa State University, Ames, Iowa, 1970.

[24]W. J. Craddock, Interregional Competition in Canadian Cereal Production. Special Study No. 12, Economic Council Of Canada, The Queen's Printer, Ottawa, 1970.

[25]Charles F. Framingham, W.J. Craddock and L.B.B. Baker, Alternative Futures for Manitoba Agriculture, A Linear Programming Analysis of Agriculture Income, Employment, Price, Production and Farm Size Policy Alternatives, Department of Agriculture Economics and Farm Management, University of Manitoba, Winnipeg. Draft publication under review.

[26]Eyvindson *op. cit.*

divided farms into three groups on the basis of gross sales. Farm size group one included all farms with gross sales of $40,000 or more. Farm size group two included all farms with unit gross sales of $10,000 to $39,999, while farm size group three included all farms with gross sales of $2,500 to $9,999. These farm size groups were the producing units for the model and a full set of crop and livestock activities was defined for each group. The model did not define separate producing units for crops and livestock as did Brokken and Heady. Production by each farm size was limited by land, pasture, labor and capital constraints. These restraints restricted production more realistically than land restraints alone. The cropland and hayland available to each farm size was divided among three quality classes. Three land constraints and three crop production activities were defined for each farm size group. Like the Brokken and Heady model, this model also allowed the use of cropland and hayland of each quality class for pasture use in case they were not used for crop production. The pasture constraint level for each farm size group was determined by deducting the animal unit months of pasture required for the exogenous livestock produced by the farms of that group in 1965 from the amount of grazing possible on the land used only for pasture by those farms in that year. The cotton land constraints limited cotton production by each farm size group to the acreage harvested in 1953. Labor constraints were specified for the crop and noncrop season. These constraints were set equal to the amount of family labor available to the farms of a size group in 1965 minus the labor required for the production of crops and livestock excluded from the model. Labor hiring activities were also included in the model. A capital constraint for each farm size was defined as total expenditures made in 1965 by the farms of that group for the production of crops and livestock considered in the model. Transportation costs of products between producing areas within a single region were included in the analysis. The model also included transportation activities to transport final and intermediate products.

All the above models were developed for the U.S. economy. Similar models were constructed either at the provincial level or for the whole economy of Canada. Craddock[27] developed an interregional linear proramming model for Canada for use in determination of the pattern and location of cereal production that would minimize the combined production and transport cost in order to meet specified levels of annual cereal demand. This model was very similar to the Brokken and Heady model. However, it was applied to the Canadian economy. In this model the Canadian economy was divided into 188 producing regions on the basis of geographical boundaries. The regions were compresed of counties in Eastern Canada, and crop districts and census divisions in Western Canada. The model included all the cereal production areas of Canada with the exception of Newfoundland and two areas in British Columbia. Producing areas were aggregated to form 29 consuming regions. One consuming region was identified in Newfoundland. With the exception of producing regions lying in Quebec, it was assumed that there were two sizes of farms on the basis of acreage in each producing region. These two sizes of farms, he referred to as small and large farms. The average size of farms within each size were different in various regions. For Manitoba, small and large farms were taken to have 250 and 650 acres respectively. Interregional transportation rates were based on flows between the central

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[27]Craddock op. cit.

points of the consuming regions. Transport costs were assumed zero for grain movement within or between producing regions within the same consuming unit.

Framingham, Craddock and Baker[28] developed an interregional linear programming model to determine the optimum location of crops and livestock that would maximize the net income of farmers in Manitoba. Unlike the Craddock study, they considered both crop and livestock activities. They divided Manitoba into 14 crop districts. Unlike the Craddock study, in order to take into account the variability in productivity, this study considered two soil types in addition to three sizes of enterprises for each crop district. Different units were used for measuring farm size for different enterprises, e.g. for crop production, farm size was measured in terms of acres, while for dairy cows, number of cows were used to measure enterprise size. For crops, small farms were defined as those having less than 240 acres, medium farms were those 240-759 acres in size, while large farms were defined as those having more than 759 acres. Like the Eyvindson model this study placed restraints according to soil types and region. In addition it included minimum employment and income constraints by farm size. The model also specified agricultural commodity demand categories and regional production restraints on a farm size specified basis. This study like all other studies omitted the question of what would be the optimum organization of agriculture if production was redistributed to efficient farm firms.

In all the earlier studies, farms of each region were either taken as a single producing unit or farms were divided between two or three size

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[28]Framingham, Craddock, Baker op. cit.

groups in order to account for the differences in production efficiencies existing on various farms. In these studies, spatial optimal organization of agriculture was determined by constraining the efficiency. The efficiency was constrained in the sense that the coeficients of average sized farms or coefficients of specific groups of farms were used while determining the optimal organization. The efficient use of resources among other things depends upon the size of the firm and the method of production. In order to produce the product at the minimum possible average cost, the firm should be of optimum size and must use the best method of production. Use of technical coefficients in earlier studies of the firms which were not employing the optimum quantities of inputs by using the most efficient methods of production meant that these firms were not producing the output at the minimum possible average cost. From this one could conclude that these firms were not economically efficient. Therefore, the optimal organization of agriculture determined by using the technical coefficients of average producing units or firms of various sizes was not strictly efficient. This study eliminates this source of inefficiency and determines the optimal organization with technical coefficients of optimum sized firms which are using the most efficient methods of production and employing the inputs in optimum quantities.

The model used in this study is a modified version of the model developed by Framingham et al.[29] The similarities between the model used in this study and the Framingham et al model are:

1. Both use the same 14 crop districts,

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[29]Ibid.

2. Both use the same two categories of soil,

3. Both use the same crop production activities, i.e. wheat, oats barley, flaxseed, rapeseed, rye, sunflowers, potatoes, sugarbeets, and

4. In both studies the optimum organization was defined as that which would maximize the net income of farmers.

The dissimilarities between the present model and that of Framingham et al[30] are that:

1. The present model unlike the Framingham et al[31] model is concerned only with crop production, while the livestock sector was taken as exogenous. The feed requirements of livestock were however, included in the product requirements for each crop district.

2. The present model unlike previous studies including Framingham's et al[32] is concerned only with the optimum sized farms which are employing the most efficient methods of production and are using the inputs in optimum quantities.

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[30]Ibid.

[31]Ibid.

[32]Ibid.

CHAPTER III

THEORETICAL CONSIDERATION

It was pointed out in the previous chapter that this study would use the technical coefficients of optimum sized farms, while determining the optimal organization of crop production. Given the optimum sized farms, the problem of determining the optimum quantities of different crops which should be produced, arises because the quantities of resources are limited. The optimum allocation of resources among crops is a matter of the relative urgency of the demands for them and their relative costs of production. No crop's optimum level of output can be determined in isolation. It can be determined only in comparison with other crops which compete for the limited resources. Because of the interdependence of different crops one can conclude that resource allocation in agriculture is a matter of general equilibrium analysis.[33]

For considering the theory underlying the present problem, the first part of this chapter is concerned with the theory of a firm in a perfectly competitive industry. The second part discusses various

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[33] For references on general equilibrium analysis see:
(1) William J. Baumol, Economic Theory and Operations Analysis, New Jersey, Prentice-Hall 1972, pp. 365-369.
(2) David Simpson, General Equilibrium Analysis, New York, John Wiley and Sons, 1975.
(3) Donald S. Watson, Price Theory and Its Uses, Second ed. Houghton Mifflin Company, Boston, 1968, pp. 272-275.
(4) Kenneth J. Arrow, "General Economic Equilibrium. Purpose Analytic Techniques, Collective Choice". American Economic Review Vol. 64, No. 3, June 1974, pp. 253-272.
(5) Blaine Robert and David L. Schulze, Modern Mathematics and Economic Analysis, New York, W.W. Norton and Co. 1973, pp. 258-288.
(6) Robert Dorfman, Paul A. Samuelson and Robert M. Solow, Linear Programming and Economic Analysis, New York McGraw Hill Book Co. 1958, pp. 346-381.

approaches to general equilibrium analysis in the light of the present study. In this part, the first section is concerned with the Walrasian approach to general equilibrium. The second section deals with the neoclassical approach to general equilibrium. The third section is concerned with the linear programming approach to general equilibrium. The third part also deals with the suitability of marginal analysis and linear programming for this study.

THEORY OF A FIRM IN A PERFECTLY COMPETITIVE INDUSTRY

Economic theory suggests that in the long run, the firm uses that size of plant and produces that level of output at which minimum average cost is equal to price and the firm makes zero profits (and zero loss). The market adjustment of the individual firm takes place by requiring the prices of commodities to fall to a level which allows continued existence of firms of optimum size having minimum average cost. Figure 1 and 2 indicate how the product prices force the firms to be of optimum size. In figure 1, SAC_1, SAC_2, and SAC_3, are the short run average costs for three firms of different sizes. Their corresponding marginal cost are MC_1, MC_2, and MC_3. The short run average cost curves (SAC) assume that one or more resources are fixed in the short run. These short run cost curves are typically "U" shaped. This is due to the fact that average costs per unit of output declines as the level of output increases as fixed costs are spread over more units. Fuller utilization of fixed resources is achieved. Finally, average cost curves start to rise as variable factors must be used in increasing proportions to the fixed resources in order to

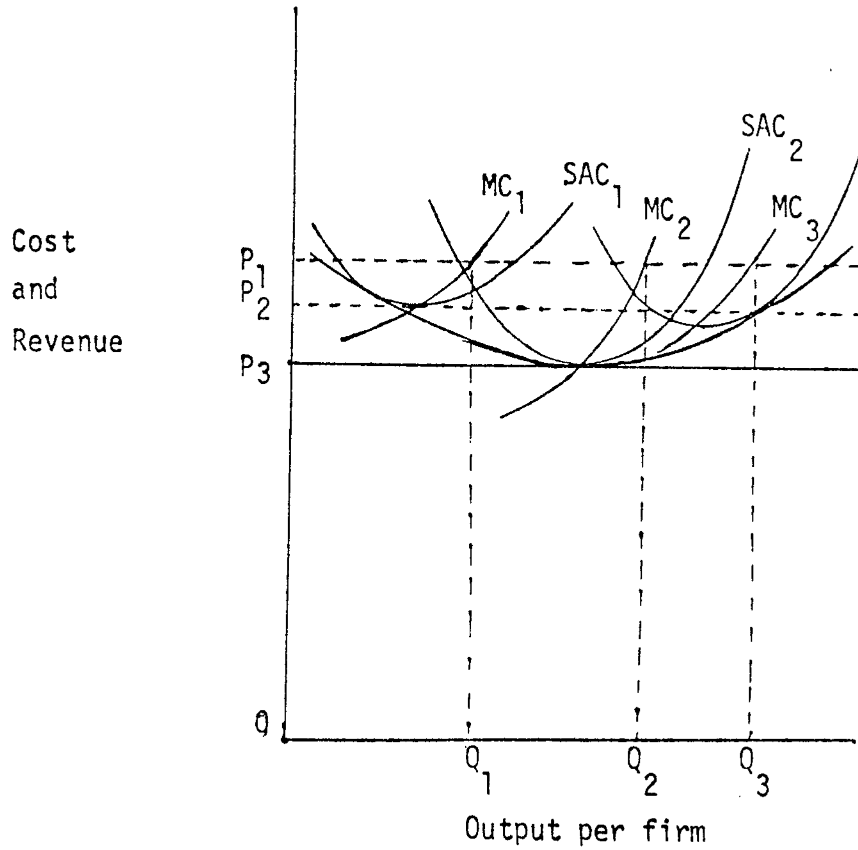

Figure 1

Long-run Equilibrium
Adjustment of a Firm

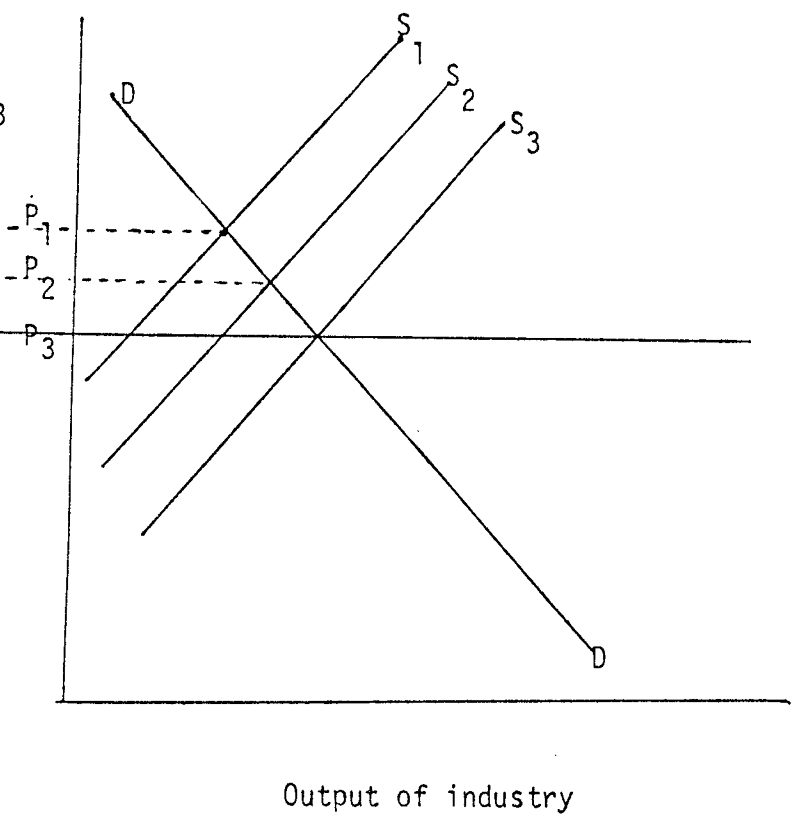

Figure 2

Longrun Market Equilibrium

achieve higher levels of output. In the long run all factors are variable and one can obtain the long run average costs curve by drawing tangents to SAC curves i.e. farm size are so numerous that even a small movement along the LAC curve involves a change in firm size as well as in the variable factors used with it.

In Figure 2, DD is the demand curve and S_1 is the original short run supply curve for the industry. Under this situation, price will be OP_1 and all the firms would earn abnormal profits. Each firm maximizes profit by producing that level of output at which marginal cost is equal to marginal revenue (i.e. in this case equal to price). Small (SAC_1), medium (SAC_2) and large (SAC_3) firms will produce OQ_1, OQ_2 and OQ_3 level of output respectively. Presence of abnormal profit encourages the new firm to enter and/or older firms to expand their size. As the number of firms increases and firms expand their size, the short run supply curve will shift to S_2 position which will produce price OP_2. Small firms (SAC_1) will go out of business because they are not covering their costs, but the medium firms (SAC_2) are still earning abnormal profit. Large firms (SAC_3) will earn small abnormal profit. There will be a tendency among medium size firms to increase in number, because they are earning abnormal profit. As this adjustment proceeds, finally a short run supply curve S_3 will be reached and the price will fall to OP_3 level. Only firms of optimum size (i.e. of minimum average cost) will stay in business. Small firms are eliminated because they are too small and large firms go out of business because they are too large. Only firms of SAC_2 size will exist in long run.

It is quite possible that some resources may be available to the firm only in specific size units, such as a quarter section of land, a tractor of a certain size. These resources are often under-utilized. For example, a tractor of a certain size may be under-utilized with 600 acres but may not be able to handle 900 acres. Due to the discrete resources, average cost curves may be discontinous. Whatever the nature of cost curves whether they are continous or discontinous in the long run only optimum sized farm firms will stay in business because they would be able to produce at the minimum possible average cost. Given the optimum sized firm, the problem of allocating scarce resources to various crops is a general equilibrium problem because of interdependence of different crops.

GENERAL EQUILIBRIUM MODELS

Walrasian Model

Leon Walras was the first person who developed a general equilibrium model. His model requires that the demand for each resource and commodity is equal to its supply. Assume that there are 1, 2 . . . n commodities and 1, 2, . . . m resources; the quantities of commodities are $X_1, X_2, \ldots X_n$; the quantities of resources $Z_1, Z_2, \ldots Z_m$; the prices of commodities are $P_1, P_2 \ldots P_n$. The prices of resources are $V_1, V_2, \ldots V_m$. The market demand equations for commodities are:

$$X_1 = f_1 (P_1, P_2, \ldots P_n; V_1, V_2, \ldots V_m)$$

$$X_2 = f_2 (P_1, P_2, \ldots P_n; V_1, V_2 \ldots V_m)$$

$$X_n = f_n (P_1, P_2, \ldots P_n; V_1, V_2, \ldots V_m) \qquad (1)$$

The demand for any resource can be given as the sum of the amounts used in all commodities. Let Aij be the quantity of the i-th resource needed to produce one unit of commodity j. Since there is no unemployment of resources, demand for each resource equals its supply, i.e.

$$a_{11} X_1 + a_{12} X_2 + \ldots + a_{1n} X_n = Z_1$$
$$a_{21} X_1 + a_{22} X_2 + \ldots + a_{2n} X_n = Z_2$$
$$a_{m1} X_1 + a_{m2} X_2 + \ldots + a_{mn} X_n = Z_m \qquad (2)$$

Since the price of each commodity is equal to cost per unit of that commodity,

$$a_{11} V_1 + a_{21} V_2 + \ldots a_{m1} V_m = P_1$$
$$a_{12} V_1 + a_{22} V_2 + \ldots + a_{m2} V_m = P_2$$
$$a_{1n} V_1 + a_{2n} V_2 + \ldots + a_{mn} V_m = P_n \qquad (3)$$

Finally, the supply of resources can be given as

$$Z_1 = s_1 (P_1, P_2 \ldots P_n; V_1, V_2 \ldots V_m)$$
$$Z_2 = S_2 (P_1, P_2 \ldots P_n; V_1, V_2 \ldots V_m)$$
$$Z_m = S_m (P_1, P_2 \ldots P_n; V_1, V_2 \ldots V_m) \qquad (4)$$

There are 2n + 2m equations for 2n + 2m unknowns, X, Z, P, V. But equations (1) and (4) have only m + n - 1 independent equations. If all prices are measured in terms of one commodity (say $P_1 = 1$) then the number of unknowns is also reduced by one. Thus the system of equation is determinate.

A number of criticisms have been made on the Walrasian model of general equilibrium described above. The most important criticism is that when the number of equations is equal to the number of unknowns, this does not guarantee that the solution is both unique and has economic meaning. For instance, the general equilibrium system may require a negative output of one or more commodities which makes no economic sense.

In Equation set (2), it is quite possible that when "m", the number of resources and equations, exceeds "n" the number of goods, then the set (2) will have no solution unless the coefficient a_{ij} and the total factor supplies Z_m are in special proportions.

The set of equations in (2) also requires that the total quantity of resources be equal to the total quantity of resources supplied. In other words, this requires that each factor is fully employed. But it is possible, that a factor is not fully used, i.e. total demand is less than the total quantity supplied even at a zero price.

Neo-Classical Approach and Marginal Analysis

In the neo-classical approach to general equilibrium, each household acts as if it were trying to maximize its utility and each firm acts as if it were trying to maximaize its profits. The outcome is a unique solution for relative prices and absolute quantities of inputs and outputs. Each output is produced and sold at its lowest unit cost. All markets are cleared and are interdependent. The system is homogeneous of degree zero, i.e. if the value of all the price variables are increased proportionately the values of the quantity variables will remain the same. This analysis is based heavily on the marginal conditions of equilibrium, i.e. the condition of equality of price ratios to the marginal rates of substitution. It requires that the transformation surface is well defined and differentiable. It emphasizes substitution possibilities as against the limited substitutability in the Walrasian model. This approach to general equilibrium has many weaknesses. They include:

1. Like the Walrasian model, where the number of equations is equal to the number of unknowns, this does not guarantee that there would be a solution which is unique and have economic meaning,

2. Production of certain outputs may require inputs in certain fixed proportions. It is impossible to substitute one input for another input in the production process. This is the case of fixed technology. In this case, although the transformation surface is well defined, it is not differentiable.

The theory of the multifactor, multiproduct firm (i.e. marginal analysis) which is an adoption of neoclassical general equilibrium analysis to the individual firm is of particular interest to our problem. It helps to allocate scarce resources available to the production of crops in such a way so as to maximize the income of the farm firm. This approach is discussed in detail in Appendix A, while its suitability to the present study is given after the next section.

Linear Programming Approach to General Equilibrium

All the problems posed by the Walrasian and Neoclassical approaches are overcome in a linear programming approach to general equilibrium. One can make "n" (the number of processes) larger than "m" (number of resources) simply by introducing more activities. Negative output problems are avoided automatically as every linear programming requires that solution real variables be non-negative.

In order to allow the non-use of resources, we can write (2) as

$$a_{11} X_1 + a_{12} X_2 + \ldots + a_{1n} X_n \leq Z_1$$
$$a_{21} X_1 + a_{22} X_2 + \ldots + a_{2n} X_n \leq Z_2$$
$$a_{m1} X_1 + a_{m2} X_2 + \ldots + a_{mn} X_n \leq Z_m \qquad (5)$$

If the strict inequality holds for any equation (i.e. resource) of set (5), then that factor will not be fully employed. Thus the equality requirement of any equation in set (2) is overcome through the introduction of inequalities which allow non use of resources.

Each equation in set (3) states that the price of each commodity is equal to its unit cost. As economic theory indicates, if the price for any commodity is greater than the unit cost, then output will tend to increase. This will reduce the price of the commodity. At the same time, the prices of the inputs that are used in the production of that commodity will rise and this would result in increasing unit cost. If the unit cost is greater than price, then output will decrease which will increase the price of the commodity and at the same time less use of resources will decrease their prices and this would lower the unit cost. Output of any commodity could fall to zero level if unit cost is greater than the price of the commodity at all positive levels of output. Output cannot be negative as it has no economic meaning. We can modify the set (3) as

$$a_{11} v_1 + a_{21} v_2 + \ldots + a_{m1} v_m \geq p_1$$
$$a_{12} v_1 + a_{22} v_2 + \ldots + a_{m2} v_m \geq p_2$$
$$a_{1n} v_1 + a_{2n} v_2 + \ldots + a_{mn} v_m \geq p_n \qquad (6)$$

If the strict inequality holds for any line of set (6), the corresponding output must be zero.

We can show that the general equilibrium system consisting of (1), (5) and (6) will give us the values of x, p, and v which are economically meaningful.

Since x and v variables cannot be negative, then the constraints of (5) and (6) become the constraints of a linear programming specification. The coefficient matrix is the same in both (5) and (6) except that it is transposed.

We can state the problem and its dual as follows:

Maximize $Y = p_1 X_1 + p_2 X_2 + \ldots + p_n X_n$

Subject to set (5) and $x_1 \geq 0$, $X_2 \geq 0$, . . . $x_n \geq 0$

The dual problem is as follows:

Minimize $M = Z_1 v_1 + Z_2 v_2 + \ldots + Z_m v_m$

subject to set (6) and $v_1 \geq 0$, $v_2 \geq 0$, . . . $v_m \geq 0$

Since there are nonnegative x's and v's which satisfy (5) and (6), both the problem and its dual will have optimal solutions, when a pair of dual problem is solved, the maximum value of the problem being maximized, i.e. $\sum_{j=1}^{n} p_j x_j$ equals the minimum value of the form being minimized $\sum_{i=1}^{m} Z_i v_i$. If we can find an equilibrium solution of the general equilibrium system which is also a solution of the pair of dual programming problems, one can say that total expenditure equal total factor returns. The converse is also true if total expenditure equals total returns in a solution of the general equilibrium system, then the linear programming problems are also solved. This equality is forced by the supply and demand functions. On the basis of the logic of linear programming, one can state:

> Hidden in every competitive general equilibrium system is a maximum problem for value of output and a minimum problem for factor return.[34]

It may be pointed out that the prices of the commodities are not determined within the system as in Walras and neoclassical models, they are interpreted as exogenously determined indicators of relative demand priorities. The output levels which are the solution to (5) are the equilibrium quantities. Once these are determined, together with the choice of processes, the quantities of input that are used follow directly from the coefficient matrix. All inputs may not be fully used. Those which are not used fully have a zero price imputed to them. The input prices determined are the equilibrium prices in the sense that when each input is valued at these prices, the average cost of every commodity produced is exactly equal to its given unit price.

In the Walras model, there was no choice of technology as the coefficients of production were fixed. In linear programming each process represents a fixed combination of inputs and we can deal with the substitution of inputs by substituting processes. The Walrasian model also assumed that all factors are fully employed. But it may be efficient if some of the inputs are not fully employed and some of the commodities are not produced at all. It is efficient in the sense that the total value of output would be higher than would be the case when it is required

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[34]Dorfman, Samulson and Solow, op. cit., p. 370.

that all inputs should be fully used, and some quantity of each commodity produced. The solution will tell us not only which alternative processes have been used, but also tell us how much of each input is used and how much of each commodity would be produced.

In the system of equations and inequalities numbered (1), (5) and (6), the unknowns are n x's, n p's and m v's. In the pair of dual linear programming problem, prices are given and x and v appear as unknown. If we take any set of nonnegative prices, the dual problems possess solutions. For any set of prices we can get the values of x's and v's from the linear programming problem. But it is quite possible that this particular set of x's, p's and v's may not satisfy the demand relations. Substitution of the p's and v's in the demand functions may produce a set of commodity outputs or x's which are not the same as were determined from the linear programming solution. If the x's obtained from the linear programming solution and those obtained from demand functions are not the same, then one should take in sequence alternative sets of p's until the x's obtained are the same. Kakutani's fixed point theorum[35] assures us that there is at least one set of p's which will yield sets of x's and v's that will also satisfy demand equations (1). A unique solution to a general equilibrium system can then be ensured if we accept the axiom of revealed perference. This approach to general equilibrium generates two important points:

1. every competitive equilibrium system implicitly contains

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[35]Robert and Schulze, op. cit., p. 282.

a maximization-of-value output problem and a minimization-of-factor returns problem;

2. unlike the Walrasian and neoclassical models, there exists a unique solution to the general equilibrium system that has economic meaning.

Optimality conditions of linear programming for a profit maximization problem are give in Appendix B, while its suitability as compared to marginal analysis is discussed in the next section.

Criticism and Suitability of Marginal Analysis and Linear Programming

Marginal analysis is concerned with the process of making choices between alternative factor-product combinations considering infinitesimal changes in factor-product combinations in a firm's production problem. The analysis is based on the production function concept. A typical formulation of this concept is by Samuelson:

> We assume as given by technical considerations the maximum amount of output, x, which can be produced from any given set of inputs $(v_1, \ldots, v_n)$. This catalogue of possiblities is the production function and may be written
>
> $$x = f(v_1, \ldots, v_n)$$
>
> In general, there will be a maximum output for each set of inputs, and so this function is single valued, and will be assumed initially to have continuous partial derivatives of desired order.[36]

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[36] Paul A. Samuelson, Foundations of Economic Analysis, Cambridge, Harvard University Press, 1948, pp. 57-58.

Profit maximization by the firm involves two decisions. The first decision is concerned with the estimation of the production function, which specifies the maximum quantity of output that can be produced by applying the specified quantities of factors. The second decision is concerned with the determination of the quantities of products that are to be produced which would maximize total profit. Marginal analysis is concerned only with the second decision of the firm since it assumes the production function(s) are already known.[37] It deals with differentiating the production, revenue and cost functions with respect to each input and output independently with the objective of maximizing the net income of the firm.

Linear programming is concerned with the optimization of a linear objective function subject to linear constraints. The common objective of a firm in agriculture is the maximization of net revenue generated by activities or processes included in the model. Unlike marginal analysis, the linear programming analysis is based on the concept of activity or process. More specifically, activity is used to indicate the things being produced, as a method of attaining the objective. A process is a method of converting resources into a product.[38] However, the term process and activity are used synonymously in this study. Linear programming can also be extended to treat both types of decision problems simultaneously.[39] This can be accomplished by considering each variation

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[37] Thomas H. Naylor, "The Theory of the Firm: A Comparison of Marginal Analysis and Linear Programming." Southern Economic Journal, Vol. 32, No. 3, January 1966, pp. 266-267.

[38] Earl O. Heady and Wilfred Candler, Linear Programming Methods, The Iowa State College Press, Ames, Iowa, U.S.A., 1958, p. 11.

[39] Naylor, op. cit., p. 267.

in technical proportions as a separate activity.

The concept of activity or process in linear programming helps us to know what lies behind the production function concept of marginal analysis. According to Dorfman:

> . . . the process of linear programming is a more specifically defined concept than the production function of the marginal analysis. Indeed, a production function is a family of processes which use the same factors and turn out the same products. If we compare any two points on a production surface, if the internal ratios of the inputs and outputs at the two points are the same, they will represent different levels of the same process, otherwise they will represent different processes. The production function is thus a tool for exhibiting and comparing different but related processes. What it fails to represent adequately is the consequence of using several processes in parallel, and such combination of processes as are characteristic of modern industry.[40]

Dorfman has mentioned how closely these two approaches are related as:

> Linear programming is clearly closely related to marginal analysis because both modes of analysis depend on formal, mathematical methods of maximization . . .
>
> So far as they purport to describe economic actions they both postulate that economic decisions are made on the basis of rational calculation. Further, to bring the problem within the scope of mathematics, they both postulate that the guiding objective of economic decisions is to maximize some measurable function of the variables under the control of the decision unit.[41]

Marginal analysis helps us to determine the optimum quantities of factors directly, whereas in linear programming optimum quantities of

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[40] Robert Dorfman, Application of Linear Programming to the Theory of the Firm, University of California Press, Berkeley 1951, p. 15.

[41] Ibid., pp. 79-80.

Naylor has similarly described the difficulties associated with second stage decision.

> . . . . the firm's second stage decision problem (profit maximization subject to constraints imposed by the production function) stems from the fact that the solution of the firms technological problem may yield a production function which does not possess such properties as continuity, concavity and non-zero first and second order partial derivatives. Although marginal analysis may be quite suitable for solving the first type of decision problem (technological problem) it may not be at all appropriate for solving the second type of decision problem . . .[44]

Marginal analysis may also be inapplicable in many situations where the price is equal to marginal cost at a negative output. For an unprofitable item marginal cost may be equal to price only at an impossible negative output level.

Similarly, linear programming has its own problems. Linear programming is of little help in estimating input-output relationships. The method can only specify the type and quantity of data needed. In cases in which a firm has an infinite number of processes, the marginal analysis of smooth curves is likely to be more appropriate than the methods of linear programming.

Finally the choice between linear programming and marginal analysis as an approach to a firm's profit maximaization problem depends on the nature of the problem being considered. In the words of Dorfman

> . . . with regard to each of his disposable resources he has two sorts of decisions to make: first, the use, if any, which he is to make of that resource, and second, the technique to be applies for using that resource for the purpose adopted. Agriculture provides an excellent example for distinguishing these two sorts of decisions. Land is normally the limiting resource. The first type of decision is exemplified by the choice of which crop to plant on each plot; the second type by the technical decisions of how intensively to plant, how much and what type of fertilizer to use, and the like.

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[44]Naylor, op. cit., pp. 267.

> Now the first type of decision is a choice among a finite number of quantitatively different alternatives. There are, to carry on the earlier example, only a finite number of different crops and like horses and apples, they are incommensurable. The second type of decision is infinitesimal and quantitative; it is a question of how much is to be used of each input and how much is to be produced of the outputs. Now the point of departure of the marginal analysis is the second type of decision whereas the point of departure of linear programming is the first.[45]

Naylor has very concisely summarized the problem of choice between linear programming and marginal analysis in a profit maximization problem.

> ....the choice between linear programming and marginal analysis as a tool of analysis depends on which problem is being considered or equivalently which level of abstraction is desired. If the problem is "What technique should be applied for using a particular resource for the purpose adopted?" then marginal analysis is more suitable. If the question is "What use, if any, is to be made of a particular resource?" then linear programming is perhaps more appropriate.[46]

The problem of determining the optimal organization of agriculture on efficient sized farms in Manitoba, given the resource restraints, is basically the problem of how to use the available resources in order to maximize the net income of farmers. Linear programming is more appropriate than marginal analysis when the question is "What use is to be made of resources?" Therefore the use of linear programming to determine the optimal organization of agriculture on farms of current efficient size is suggested as it involves basically the choice among crops which should be grown in order to maximize the net income of the farmers from the given resources. Moreover, the linear programming approach to general equilibrium overcomes all the problems associated with the Walrasian and neoclassical approaches, in particular it does not allow the negative level of output of crops. Finally, linear programming, where the criteria of marginal analysis remain applicable,

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[45] Dorfman, op. cit., p. 84

[46] Naylor, op. cit., pp. 267-268.

permits the incorporation of many relationships and variables into a set of equations and allow simultaneous determination of production patterns for many regions. Marginal analysis does not provide any direct means of finding the optimal organization in such a large scale problem.

CHAPTER IV

METHODOLOGY

In Chapter One we indicated the general importance of the problem and the adjustment of farms towards the optimum size. The objectives of the study were also given. Chapter Two reviewed various inter-regional studies which have been conducted to determine the optimum organization of agriculture in the U.S.A. and Canada. Chapter Three discussed the theory of perfectly competitive firms and various types of models which can be used for the efficient allocation of resources. Finally it was concluded that for analysis of a problem concerned with the optimum organization of crops that would result, given "efficient" farm size, linear programming was a suitable technique. The model to determine the potential optimum organization of crop production is discussed in this chapter. The chapter is divided into two sections.

Section I is concerned with the determination of efficient or optimum farm[47] size. For this purpose, three approaches (i.e. regression, economic engineering and survivor analysis) were considered. Because of the simplicity and availability of data the survivor approach was used for determining the efficient farm size. This technique suggests that the firms having the minimum average total cost are the best to survive in a common market where all the firms sell. The competition among firms of different sizes selects out the firms which are most efficient. It helps in finding the efficient size by determining the share of industry output coming from firms of different sizes over time.

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[47]Efficient or optimum size refers to the range over which average total costs, as defined by the long run average cost, are at a minimum.

If the share of a particular size in the total output is increasing, then that size lies within the range of optimum size, while if the share of a given size is decreasing then that size lies outside the range of optimum size. Use of this technique on farms of different sizes resulted in concluding that farms having 760 acres and over are in the optimum range. These farms may not be equally efficient, but it was assumed that they are efficient for the present study as they all lie in the optimum range.

Section II deals with the assumptions, the specific model and the data used in this study for the analysis of the implications of "efficient" sized farms. Briefly, in order to determine the optimum organization of crops on these efficient farms, Manitoba was divided into 14 crop districts. Fifteen production activities were considered. They were: wheat for export, oats for export, barley for export, flax-seed, rapeseed, rye, sunflowers, potatoes, sugarbeets, wheat for feed, oats for feed, barley for feed, wheat produced for sale as feed, oats produced for sale as feed, and barley produced for sale as feed.

"Grain for feed" activities were specified in order to supply the feed to livestock in the same crop district. "Grain produced for sale as feed" activities were specified in order to supply the feed to some other adjacent crop districts as the total feed requir-ement of each crop district could be fulfilled either by producing in the same crop district or obtaining it from adjacent crop districts. Constraints utilized in the study included:

1. Land availability constraints: Total amount of land available in each crop district was arrived at by projecting the crop

and summerfallow area to 1976. From this projected area, tame hay area was deducted to find the area available for crops. This area was then partitioned into two soil types.

2. Maximum production constraints: These constraints were set by utilizing the highest level of production or highest normal production of different crops over the period 1962-75.

3. Minimum production constraints: These constraints were set in a way similar to the maximum production constraints except that minimum levels of production were used. Maximum and minimum production constraints were specified by considering the actual or normal production instead of using maximum and minimum flexibility constraints because of the static nature of the model.

4. Minimum demand constraints for each crop district: Minimum feed demand constraints for metabolized energy from wheat, oats and barley were established at the normal requirement of livestock. This energy could come from either wheat or oats or barley; that is substitution between the three is allowed. Normal livestock requirements per animal unit for each crop were first determined by dividing the projected animal requirement by the projected number of animal units in 1976 for Canada. These average requirements per animal unit were then multiplied by the availability of metabolized energy per bushel. The resulting figure was then multiplied by the projected number of animal units in each crop district. These figures were then added in order to establish the constraints.

5. Minimum demand constraints for Manitoba: Minimum constraints for wheat, oats and barley were established by adding the human food

demand, export demand and industrial demand to the normal animal demand for Manitoba as a whole. Normal per capita human food demand for each of these crops was determined by projecting the human food demand for Canada to 1976 and then by dividing the total population of 1976. These average requirements were then multiplied by the population of Manitoba. Industrial demand was determined by estimating the total production and total industrial use of each of these crops to 1976. It was assumed that the contribution made by each province was equal to the proportion of the total quantity used for industrial purposes to total production. The procedure used for export demand was identical to the industrial demand. The procedure used for establishing constraints for flaxseed, rapeseed, and rye demand was identical to the previous one except that there was no livestock requirement. Minimum demand restraints for sunflowers, potatoes and sugarbeets were set at the minimum level of production of these crops over the 1962-75 period.

The cost of production of crops and the method of yield and price estimation are also discussed in this chapter.

I. DETERMINATION OF EFFICIENT FARM SIZE

Before determining an efficient farm size, it is necessary to define the term size. Renborg defined size as:

> The size of the firm is some measure of the total sum of all the means of production which firm commands. The means of production can be thought of as a vector, B, whose elements are the amount of each means of production measured in technical units.... . The size of the firm is thus specified in as many dimensions as there are elements in B. ....If some elements....decrease in size at the same time as others .... increase - e.g., a substitution

> is taking place - it is not possible to tell if it is a total size increase or decrease taking place .... it is possible to say that the firm has increased in size in some dimensions ... and decreased in some other dimensions ...[48]

This definition establishes the point that a single measure offers difficulties. But there are several single measures of farms size as number of acres, gross value of production, number of workers, total cost, net returns etc.. When we see the census data, we are forced to use single measure classification. A single measure is usually selected by how well it serves as a base for the particular kinds of size comparison to be made. Like census reports, farm size was measured in terms of acres in this study because acreage is a useful measure when one is concerned with crop production, while it may be a poor measure for poultry operation.

Given the farm size measure in terms of acres, equilibrium in a perfectly competitive industry requires that each of the firms as well as the industry as a whole be in equilibrium. A firm in the industry will be in equilibrium when it is earning maximum profits by equating marginal revenue with marginal cost. The industry as a whole will be in equilibrium when there is no tendency for firms either to enter or to leave the industry. This will only occur when all the firms in the industry are earning normal profit [49] to induce them to stay in the

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[48]Ulf Renborg, "Growth of the Firm in Relation to Problems of Factor Acquisition - the Swedish Experience" in Market Performance and Firm Growth, Joint Comm. Rept. 1, Joint Conf. Farm Management and Marketing Res. Comm., Western Agr. Econ. Res. Council, Las Vegas, November 1967, p. 18.

[49]Normal profits are those which are just sufficient to induce the firm to stay in business.

industry and there are no incentives for new firms to enter. The perfectly competitive model can be used to make valid predictions about firm behaviour.[50] In a perfectly competitive long run model, the firm uses that size of plant and produces that level of output at which minimum average cost is equal to price and the firm makes zero profit (and zero loss).[51]

In Manitoba agriculture, where farm firms of different sizes exist, they earn different levels of profits. Farm firms of larger size have lower per acre cost as compared to smaller sized farms. Referring to the Framingham et al [52] study and considering the production of wheat which is grown in crop district one, cost of production per acre amounted to $35.72 on small sized farms (i.e. less than 240 acres), $28.86 on medium sized farms (i.e. 240-759 acres) and $26.16 on large sized farms (i.e. over 759 acres); while the gross income on all these farms amounted to $31.67. Profits of $5.51 per acre were earned by large sized farms, while losses of $4.05 per acre were experienced on small sized farms. The prescence of profits on large sized farms and losses on small sized farms has created a tendency for large sized farms to increase in number and smaller sized farms to decrease in number.

Various procedures have been used to determine the optimum size. These include:

1. Use of regression analysis of average cost and volume data.

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[50]The Chicago School of Economics has tended to use the assumption of atomistic market, which closely approximate perfect competition. See Henery L. Miller Jr., "On the Chicago School of Economics" Journal of Political Economy, Vol. 70, No. 1, Feb. 1962, pp. 64-69.

[51]See Alfred W. Stonier and Douglas C. Hague, A Textbook of Economic Theory, Urwin Brothers Ltd., London, 1963, pp. 126-138, and C.E. Ferguson: Microeconomic Theory, Homewood; Richard D. Irwin, Inc., 1972, pp. 270-80.

[52]Framingham, Craddock and Baker, op. cit.

2. Economic engineering method.

3. Survivor analysis

Use of Regression[53]

This method involves the determination of average costs and volumes for each of a group of sample plants. A regression line is fitted to the data which shows the average relationship between plant volume and costs. This method combines and confuses cost changes that are accompanied from the more complete utilization of a plant of a given scale with the cost changes that accompany changes in scale. Heterogeneity of products and of operating conditons, differences in the basis of valuation of physical assets, the operation of many plants below their optimum volumes and other problems[54] made it impractical to determine the longrun average cost curve. Unavailability of relevant data was another obstacle.

Economic Engineering Method

This technique requires some fairly technical information and some crude guesses on non-technical aspects such as marketing costs. Hypothetical firms are developed and estimates are obtained for cost and output. Estimates are usually based on the assumption that:

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[53]See R.G. Bressler Jr., "Research Determination of Economies of Scale", Journal of Farm Economics, Vol. 27, No. 3, 1945, pp. 526-539.

[54]Sheldon W. Williams and James W. Grubele, "Estimating Optimum Size of Food Processing Plants by Using Survivor Analysis." American Journal of Agricultural Economics, Vol. 58, No. 4, Nov. 1976, pp. 740-744.

1. All factor supply curves are completely elastic, i.e. factors of production are freely available at a constant supply price,

2. The demand for the product is also completely elastic. Even the ideal results do not tell the optimum size of firm in an industry because they do not take into account all factors in the environment in which plants operate.[55]

Survivor Analysis

The survivor technique is a relatively simple means of estimating the optimum size. It avoids the problems associated with the previous techniques. Because of its simplicity and availability of data on the number of farms in different sizes, this technique was used in determining the optimum size in this study. This technique[56] is based on the concept that the minimum average cost size firms survive best in a common market where all the firms sell. The competition among different sizes of firms selects out the most efficient firms. The technique helps in finding the efficient firm size by determining the share of industry output coming from different sizes of firms over time. If the share of output of a given size is increasing its industry output, then that size lies within the range of optimum size; while if the share of a given size falls, then that size lies out of the range of optimum size. In general, the more rapidly the share of a given size is falling, the more inefficient that size is considered to be.

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[55] Ibid., pp. 740-741.

[56] See Thomas K. Saving, "Estimation of Optimum Size of Plant by the Survivor Technique", Quarterly Journal of Economics, Vol. 75, No. 4, 569-607, 1961 and George J. Stigler, "The Economies of Scale", Journal of Law and Economics, Vol. 1, No. 1, 54-71, 1961.

Percent contribution of different sizes of farms to total value of output in Manitoba was determined by considering the value of different crops grown on different size categories for 1951, 1961, 1966 and 1971. For 1951,[57] all the crops reported in the census were considered. For 1961[58] and 1966,[59] all the crops mentioned in census reports with the exception of soybean and tobacco (which accounted for 0.01% and 0.03% respectively of the total cropped area during 1961 and 1966) were taken into account. Yield per acre[60] and the price per unit of output of soybean and tobacco were not available. For 1971,[61] field beans, oats cut for fodder, other fodder crops and soybean, which accounted for 0.01% of the total crop area, were not taken into consideration for the same reasons. While finding the contribution of different size farms to total agricultural output in Manitoba, it was assumed that yield per acre and the price per unit of output of different crops is the same for all sizes. The percent contribution of different size farm firms over time is given in Table 2.

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[57]Dominion Bureau of Statistics, Ninth Census of Canada, Agriculture Vol. VI, Part 2, Queen's Printer, Ottawa, 1953.

[58]Dominion Bureau of Statistics, Census of Canada, Agriculture, Manitoba Cat. 96-537, Vol. V, Part 3, Queen's Printer, Ottawa, 1963.

[59]Dominion Bureau of Statistics, Census of Canada, Agriculture Manitoba, Cat. No. 96-608, Vol. V, Part 1, Queen's Printer, Ottawa, 1968.

[60]See Manitoba Department of Agriculture and Immigration, Report on Crops, Livestock etc; Crop Bulletin No. 130, Queen's Printer, Winnipeg, December 1951; Manitoba Department of Agriculture and Conservation, Report on Crops, Livestock etc; Crop Bulletin No. 140, Queen's Printer, Winnipeg, December 1961; also Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Queen's Printer, Winnipeg, 1966 and 1971.

[61]Statistics Canada, Census of Canada, Agriculture, Manitoba, Cat. No. 96-708, Vol. IV, Part 3, Queen's Printer, Ottawa, 1973.

TABLE 2

PERCENT CONTRIBUTION OF DIFFERENT SIZE FARMS TO TOTAL MAJOR CORP OUTPUT OVER TIME[1]

Size (Acres)	1951	1961	1966	1971
Under 3	0.001	0.001	0.001	0.000
3-9	0.045	0.012	0.010	0.004
10-69	0.791	0.466	0.349	0.275
70-239	14.017	10.127	7.179	5.625
240-399	29.403	23.516	18.790	14.280
400-559	20.173	20.818	19.291	16.749
560-759	16.710	18.313	19.312	18.336
760-1119	11.480	15.035	18.309	21.116
1120-1599	4.782	7.104	9.410	12.066
1600-2239	1.480	2.520	3.853	5.314
2240-2879	0.293	0.675	1.194	1.990
2880-Over	0.825	1.414	2.302	4.245
	100.000	100.000	100.000	99.999

[1] Data used are taken from various sources. See Footnotes 57-61.

From the table, it is clear that the share of total output contributed by sizes under three acres, 3-9 acres, 10-69 acres, 70-239 acres and 240-399 acres has decreased consistently over time. The contribution of farm size 400-559 acres increased slightly over 1951 and 1961, and then decreased consistently. The percent contribution of 560-759 acres increased over the period 1951 and 1966 but decreased over 1966 and 1971. This could occur due to the fact that optimum farm size has changed over time because of changes in factor prices or technology. Thus farm size of 560-759 acres may have been in the range of optimum farm size over 1951 and 1966, while it may have been outside the optimum range over 1966 and 1971. The share of farms of sizes 760 acres and over has increased consistently between 1951 and 1971.

In order to see how rapidly a given farm size is gaining or losing its share of the total Manitoba crop output, an index of growth of crop output of different sizes of farms was prepared (Table 3). Index of growth was calculated by using the following formula:

$$In_{ij} = \frac{PR_{ij}}{PR_{i}1951} \times 100$$

Where:

PR_{ij} = percent contribution to total output by the i-th size in years 1961, 1966, 1971.

PR_{i1951} = percent contribution to total output by the i-th size in year 1951.

In_{ij} = index of growth of output of i-th size in the j-th year over 1951.

TABLE 3

INDEX OF GROWTH OF CROP OUTPUT OF DIFFERENT SIZE FARMS OVER TIME[1]

Size (Acres)	1951	1961	1966	1971
Under 3	100.00	100.00	100.00	0.00
3-9	100.00	26.67	22.22	8.88
10-69	100.00	58.91	44.12	34.77
70-239	100.00	72.24	55.07	40.13
240-399	100.00	79.98	63.91	48.57
400-559	100.00	103.20	95.63	83.02
560-759	100.00	109.59	115.57	109.73
760-1119	100.00	130.97	159.49	183.94
1120-1599	100.00	148.56	196.78	252.32
1600-2239	100.00	170.27	260.34	359.05
2240-2879	100.00	230.38	407.51	679.18
2880-Over	100.00	171.39	279.03	514.55

[1]Based on Table 2.

The index of growth of output of different size categories depicts that the smaller farm sizes up to 559 acres have a negative rate of growth over time. Farms of size 560-759 acres experienced an increase in the rate of growth (in terms of percentage contribution to total output) over the period 1951 to 1966 and then a declining rate of growth over the period 1966 to 1971. It may be hypothesized that the smaller the farm size, the more inefficient they are and the more rapidly the index of growth of crop output declines. Farms of 760 acres and over experienced an increase in the index of growth of crop output for the cropping patterns existing over the period 1951-71. This increase in the index of crop output was not the same for these different farm size groups. A question arises, which is the efficient size when various farm size groups observed different increase in the index of growth of crop output? Stigler[62] argued that one should not infer that size class whose share is growing more rapidly is more efficient than other classes whose share are growing more slowly because the difference merely represents difference in the quantities of various qualities of resources. By using this argument we can conclude that despite the fact that various farm size groups above 759 acres experienced different rates of growth of crop output, they are all in the efficient range. These farms of 760 acres and over are assumed to be "efficient" for the present study.

THE MODEL

Inter-regional relationships in agriculture are important because producing units are spatially distributed. There are regional differences

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[62]Stigler, op. cit.

in soil fertility, climate and in the availability of various inputs. Due to these factors, different regions have comparative advantage in the production of different crops. An efficient spatial allocation of different crops and resources requires the consideration of regional production possibilities and interregional relationships. In order to find the optimal organization of crops in Manitoba on efficient farms (i.e. 760 acres and over) a static linear programming model was used. The nature of conclusions that can be drawn from the static deterministic or probabilistic models is discussed by Rescher.[63]

"A deterministic law (universal conclusion) is one of the form 'state X is always and invariable followed by state Y'. A probabilistic law may have a form such as 'state X is followed by state Y with probability h and by state Z with probability (1-h)."

Concentrating on probabilistic elements, there are two ways in which probability can be specified--objectively and subjectively.[64]

The objective probability approach emphasize the relative frequency of occurrence of events. Using the principle of maximum likelihood[65] the observed frequency is taken to be an accurate measure of the probability of the event in any evaluation of a system. The central limit theorem[66] assures us of the correctness of such a procedure for a large number of

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[63] N. Rescher, "Discrete State Systems, Markor Chains and Problems in the Theory of Scientific Explanations and Prediction." Philosophy of Science, Vol. 30, No. 22, 1963, p. 325.

[64] R. Carnap,"The Two Concepts of Probability," in Readings in the Philosophy of Science, eds. H. Feigl and M. Brodbeck, Appleton-Century-Crofts, Inc., 1953, pp. 438-455.

[65] Taro Yamane, Statistics, an Introductory Analysis, Harper and Row publishers, New York, 1973, pp. 194-200.

[66] M. Melnyk, Principles of Applied Statistics, Pergamon Press Inc., New York, 1974, p. 220.

observations, but otherwise we have no such assurance. The subjective probability approach emphasizes the individual's degree of belief. The use of a probabilistic model leads to better decisions if one is sure that the probabilities are accurate. But there is no way by which they can be known to be accurate.

One can say that the probabilistic model is less useful than the deterministic model because a policy maker would prefer to choose an outcome rather than a distribution of outcomes.

Limited number of observations about the yield per acre with recommended levels of fertilizer also forced us to use the deterministic model because the central limit theorem assures us correctness only when the number of observations is large.

Models are also appraised in general terms by using the criteria of communicability and workability. The logic of a deterministic linear programming model is easier to communicate than that of a probabilistic model. In terms of workability, the probabilistic model may be either unsolvable or solvable at larger cost as compared to the deterministic model.[67]

It was for the reasons discussed above that a deterministic multiregional linear programming model was used in this study to determine the optimal organization of crop production.

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[67]J.R. Anderson, "An Overview of Modelling in Agricultural Management." Review of Marketing and Agricultural Economics, Vol. 40, No. 3, Sept. 1972, pp. 111-121.

ASSUMPTIONS OF THE MODEL

The assumptions in the model employed are described below.

Farmers Aim to Maximize Their Profit

It may be said that maximization of profit[68] is a part of every firm's objective function, but it may not be the only motive. Most farmers have as a final goal a high level of living and maximum satisfaction for the family.[69] Firms may not be maximizing their profits consiously, but the competitive market will force them to become so. If the farm firms do not maximize their profit under competitive market conditions, they will be forced out of business. Thus profit maximization can be considered as a valid goal of the farmers.

Markets are Competitive

Knoh[70] and Watson[71] stated that most agricultural markets and many factor markets as well, approximate perfect competition. For the commodities which we have included in our model, there are large numbers of producers who are producing almost homogeneous products. No producer is strong enough to influence the products prices. Prices of the inputs are also not influenced significantly by any producer. Farmers are

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[68]Profit is defined as the difference between the total revenue and total cost, C of the firm. Total revenue of a firm operating under perfectly competitive market can be given as the number of units of product sold, q, multiplied by the unit price, P received. Thus $\pi = Pq - C$ and profit equals net revenue.

[69]Earl O. Heady and Harold R. Jensen, Farm Management Economics Prentice Hall, Inc., Englewood Cliff, N.J., 1954, pp. 8-9.

[70]James V. Knoh, Industrial Organization and Prices, Prentice Hall Inc., Englewood, New Jersey, 1974, pp. 16-21.

[71]Donald S. Watson, Price Theory and It's Uses, Second Edition, Houghton Mifflin Co., Boston, 1968, p. 117.

normally price takers rather than price makers. Therefore, the assumption of perfect competition seems realistic.

Linear Enterprise Functions

It is assumed that linear enterprise functions for firms of 760 acres and over are an adequate representations of efficient crop firms for purpose of the analysis. This assumption implies that there are constant returns to scale or that the production function for each enterprise is linear i.e. if the production of one unit of a product needs two hours of labor and one dollar expenditure of capital, then the production of two units of output will require four hours of labor and two dollars expenditure of capital. This linear assumption is quite consistent with economic theory. It should be made clear that the familiar curvature of production function results from the changes in proportion of various factors and by the changes in scale. This linearity assumption simply says that if we take a point on the production function and if we multiply each input and output by the same constant, the relevant point will be also on the production function. In other words the linear assumption implies that production functions are homogenous of degree one. Thus as long as resources are available on farms of 760 acres and over and it is possible to duplicate the production facility, then each duplication will be as productive as the original facility. Therefore, the assumptions of linear enterprise functions for forms of 760 acres and over has some validity in this study.

Divisibility of Resources and Activities

This assumption implies that output can be produced and inputs can be used in fractional units, i.e. it is possible to use 0.51 acres of land to produce 13.5 bushels of a commodity. It may not be possible to apply certain inputs like tractors in fractional units, but their services can be obtained in any quanitiy, i.e. it is possible to hire the tractor for 1.5 hours. Buying and selling such services among farmers in aggregate will overcome the divisibility problem. Thus the assumption of divisibility is justified in our study.

Finite Number of Activities and Resource Restrictions

If there are an infinite number of alternative activities and resource restrictions, then it is not possible to find an optimal solution. It is realistic to assume that farm situations involve only a finite number of activities and restraints. For the present study, it is assumed that nine crops (i.e. wheat, oats, barley, flaxseed, rapeseed, rye, sunflowers, potatoes and sugarbeets) which constituted 95.8 percent of the total cropped area excluding tame hay were an adequate set to explain Manitoba crop production. It was also assumed that there were a finite number of land constraints, maximum and minimum levels of production of crops restrictions and demand restraints. Due to the finite number of crop activities and number of restraints, this assumption is justified.

Nonnegativity of Decision Variables

This assumption is satisfied in crop production because it does not make sense to grow minus ten acres of wheat or to transport negative one hundred bushels of wheat.

It is assumed that there are 14 interdependent but spatially separated regions.

All producers in a given region have identical input-output coefficients and these coefficients are constant for given soil types.

It is also assumed that total production in each region is limited by the availability of land and by the maximum and minimum actual or normal level of production of each crop over the period 1962-75. This range of production represents the maximum level of adjustment allowed to farmers producing each commodity. Flexible constraints were not used in establishing this range because of the static nature of the model.

MATHEMATICAL PRESENTATION OF THE MODEL

The model was applied to 14 crop districts of Manitoba. Two soil types and nine crops were considered. The objective of the model was to maximize total net income given the land, production and consumption constraints. Algebraically, the model is summarized below.

$$\text{Maximize } Y = \sum_{i=1}^{14} \sum_{j=1}^{2} \sum_{k=1}^{15} r_{ijk} X_{ijk} - \sum_{i=1}^{14} \sum_{v=1}^{14} \sum_{k=13}^{15} t_{ivk} T_{ivk}$$

subject to the following constraints.

<u>Land Availability</u>

$$\sum_{k=1}^{15} a_{ijk} X_{ijk} \leqslant L_{ij} \quad \text{for all i and j.}$$

<u>Production Maximums and Minimums</u>

$$\sum_{j=1}^{2} b_{ijk} X_{ijk} \leqslant MAPR_{ik} \quad \text{for all i and k = 1-9}$$

$$\sum_{j=1}^{2} b_{ijk} X_{ijk} \geqslant MIPR_{ik} \quad \text{for all i and k = 1-9}$$

Minimum Feed Demand Constraints for Each Crop District

$$\sum_{k=10}^{12} \sum_{j=1}^{2} M_k \, b_{ijk} \, X_{ijk} \pm \sum_{k=13}^{15} M_k \sum_{v=1}^{14} \cdot \quad T_{ivk} \geqslant D_i \quad \text{for all } i$$

Minimum Demand Constraints for Manitoba

$$\sum_{v=1}^{14} \sum_{j=1}^{2} b_{ijk} \quad X_{ijk} \geqslant D_k \quad \text{for} \quad k = 1\text{-}9$$

Non-negativity Constraints

$$X_{ijk} \geqslant 0$$

$$T_{ivk} \geqslant 0$$

Where:

Y = Net income

r_{ijk} = Net income for the k-th crop activity in the i-th region for the j-th soil type

k = 1, wheat for export

k = 2, oats for export

k = 3, barley for export

k = 4, flaxseed

k = 5, rapeseed

k = 6, rye

k = 7, sunflowers

k = 8, potatoes

k = 9 sugarbeets

k = 10, wheat for feed

$k = 11$, oats for feed

$k = 12$, barley for feed

$k = 13$, wheat produced for sale as feed

$k = 14$, oats produced for sale as feed

$k = 15$, barley produced for sale as feed

$j = 1$, sandy soil

$j = 2$, clay soil

$i = 1, 2 \ldots 14$ crop districts

X_{ijk} = Level of production of k-th activitiy in the i-th region for the j-th soil

t_{ivk} = Cost of transportation per unit of the k-th product from (to) the i-th region to (from) the v-th region

T_{ivk} = Quantity of the k-th commodity transported from (to) the i-th region to (from) the v-th region

a_{ijk} = Amount of land needed per unit of commodity k in the i-th region for the j-th soil

L_{ij} = Soil of quality j available in the i-th region

b_{ijk} = Per unit yield of commodity k for the i-th region on soil j

$PAPR_{ik}$ = Maximum level of production of commodity k in the i-th region over the 1962-1975 period

$MIPR_{ik}$ = Minimum level of production of commodity k in the i-th region over the 1962-1975 period

M_k = Metabolizable energy provided per unit of commodity k

D_i = Total amount of metabolizable energy demanded for livestock in the i-th crop district

D_k = The total demand for human food, export, industrial use and for livestock for the k-th commodity for Manitoba

THE DATA

The model given above is a modified version of the model developed by Framingham, Craddock and Baker.[72] Most of the data requirements were fulfilled by making specific adjustments to the data used in their study. The restraint levels were determined by collecting data from different sources and projecting to 1976. The procedure adopted in establishing different constraints is discussed first. This is followed by discussion of the cost of production of different crops. Finally, the method of yield and price estimation for different crops is given.

METHODS USED IN CONSTRAINT ESTIMATION

Land Availability Constraints

Total land that would be available for the production of crops in each crop district was determined by projecting the total crop and summer fallow area over time to 1976. (Appendix C, Table 1). For this purpose, the following equation was used to estimate available land, employing regression analysis.[73]

$$TAC_{it} = a_i + b_i X_t$$

Where

TAC_{it} = Total crop and summerfallow area in year t for i-th region

a_i = intercept of the equation for the i-th region

b_i = Regression coefficient showing the annual change in the crop and fallow area for the i-th region

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[72] Framingham, Craddock and Baker op. cit.

[73] Overall regression and regression coefficients were significant at the 5 percent level for half of the crop districts.

X_t = Trend variable such that $X_t = 1$ for 1961 and $X_{t+5} = 6$ for 1966 and $X_{t+10} = 11$ for 1971.

Area available for the production of crops for each crop district was arrived at by deducting the tame hap area grown in 1976 from the total projected available land. The results are shown in Table 4. The crop area was then partitioned into soil type 1 and soil type 2. by using the proportionate share of these two types of soils used by Framingham et al.[74] The area of each soil type available in each crop district is given in Table 5.

Production Constraints

Maximum and minimum production restraints were imposed in order to account for farmers desire for diversity and to depart from established levels of production. A conglomeration of factors is responsible for farmers' inability or unwillingness to make large changes in their established levels of production. These include risk and uncertainty associated with weather and marketing, imperfect knowledge and personal preferences as objectives other than profit. Since these factors cannot be measured easily, so maximum and minimum actual or normal production of each crop over 1962-75 was used as an alternative measurement of extent of diversity. Equilibrium of an efficient firm is influenced by a number of factors like price of input, price of output, technology and weather conditions. Given the prices of inputs and outputs, and technology used by efficient sized firms it was assumed that the total production by all firms of each commodity would not increase or decrease by more than the maximum or minimum production over the period 1962-75.

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[74] Framingham, Craddock and Baker op. cit.

TABLE 4

LAND AREA AVAILABLE FOR THE PRODUCTION OF CROPS

Crop District	Total Area Available[1]	Tame Hay Area[2]	Area Available for Crops
	---------------------	Acres	---------------------
1	1,033,246	110,663	922,583
2	1,102,189	40,278	1,061,911
3	1,998,940	162,673	1,836,267
4	376,646	51,554	325,092
5	1,071,771	234,536	837,235
6	170,505	12,680	157,825
7	866,725	108,371	758,354
8	865,120	78,082	787,038
9	764,736	14,299	750,437
10	1,300,446	35,198	1,265,248
11	979,385	212,674	766,711
12	924,095	34,225	889,870
13	509,002	92,828	416,174
14	511,787	256,469	255,318

[1]Projected

[2]Statistics Canada, Census of Agriculture 1976

TABLE 5

AVAILABLE SOIL TYPE 1 AND 2 AREA IN DIFFERENT CROP DISTRICTS[1]

Crop District	Soil Type 1	Soil Type 2
	acres	
1	916,309	6,274
2	690,242	371,669
3	30,849	1,805,418
4	81,273	243,819
5	301,405	535,830
6	142,043	15,782
7	583,933	174,421
8	543,056	243,982
9	232,635	517,802
10	1,138,723	126,525
11	581,014	185,697
12	569,517	320,353
13	--	416,174
14	171,063	84,255

[1] Soil type 1 and soil type 2 area for each crop district was obtained by using the proportionate share of these two types of soils as was used by Framingham et al. See Framingham, Craddock and Baker op. cit.

This range of production represents the maximum level of adjustment allowed to farmers producing each commodity. The actual level of production of various crops may undergo changes more than those specified in the maximum and minimum constraints. However, information obtained through the model would show the direction of changes in the production of various crops. The maximum and minimum level of production of wheat, oats, barley and flaxseed for different crop districts, over 1962-75 is given in Table 6. Since no data were available for other crops according to crop districts, the following steps were taken in establishing maximum and minimum levels of production constraints for these crops for each crop district:

Firstly, production of wheat was projected to determine the "normal" production for each crop district and for Manitoba as a whole for 1975 by using data from the Yearbook of Manitoba Agriculture, Table 2 in the Appendix C. The word normal is used to mean the trend level of of production rather than actual production. Due to various types of uncertainties, the normal level of production may not be the same as the aggregate output of all firms determined under equilibrium where they were using their resources efficiently. Normal production is assumed to include the effect of all variables which could influence production. The normal level of production was selected because it was assumed that the decision about the total production of commodities by farmers was not influenced by weather conditions. Normal production thus eliminated the effect of favourable and unfavourable weather and indicated long run production trends. Another reason for using normal production was to include the effect of technological change which is occurring over time.

TABLE 6

MAXIMUM AND MINIMUM PRODUCTION OF WHEAT,
OATS, BARLEY AND FLAXSEED IN DIFFERENT
CROP DISTRICTS OF MANITOBA OVER THE PERIOD 1962-1975

Crop District	Wheat		Oats		Barley		Flaxseed	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
	---------------------thousands of bushels							------------------------
1	2,927	8,859	2,378	5,953	849	7,469	704	2,022
2	3,981	11,246	3,639	9,615	761	12,689	495	1,431
3	5,774	18,314	6,344	17,627	1,431	19,056	1,269	5,069
4	665	2,399	1,687	4,156	370	4,307	122	307
5	2,612	8,342	4,301	11,749	881	8,370	315	1,171
6	235	872	312	1,751	40	777	30	158
7	2,480	6,331	3,839	6,229	829	7,168	249	873
8	2,251	7,044	3,223	8,661	534	7,768	235	968
9	1,795	6,084	2,488	7,662	738	4,282	218	831
10	3,475	11,831	3,887	7,702	4,110	12,298	218	1,183
11	1,962	7,920	3,641	6,995	1,183	7,429	129	902
12	484	2,443	1,060	3,189	228	3,296	144	509
13	824	4,065	1,128	3,168	1,624	5,118	27	118
14	714	2,977	1,685	3,256	186	2,592	137	488

Source, Manitoba Department of Agriculture, Yearbooks of Manitoba Agriculture, Queen's Printer, Winnipeg, 1962-75.

Use of normal production thus included the effect of technological change which is continuous. The following equation was used to estimate normal production:

$$PR_{iwt} = a_{iw} + b_{iw}\ X_T$$

Where:

PR_{iwt} = Production of wheat in the i-th region in period t,

a_{iw} = Intercept for wheat for the i-th region,

b_{iw} = Regression coefficent showing the annual change in wheat production in i-th region,

X_t = Trend variable such that

$$X_t = 1 \text{ for } 1962$$

$$X_{t+1} = 2 \text{ for } 1963$$

$$\vdots$$

$$X_{t+12} = 13 \text{ for } 1974$$

Secondly, production of rye and rapeseed was projected for 1975 by using the aforementioned equation for Manitoba[75].

Thirdly, normal production for rye and rapeseed for each crop district as given in Table 7 for 1975 was determined by distributing the normal production of these crops amoung crop districts in the same proportion as the normal wheat production was distributed. Wheat was used for apportioning the normal production of these crops because it was the most important crop in Manitoba and shared about 50 percent of the area of crops considered in this study. For this purpose, the following formula was used -

[75]Overall regression equations and regressions coefficients were significant for rapeseed and nonsignificant for rye.

TABLE 7

NORMAL PRODUCTION OF RAPESEED AND RYE IN DIFFERENT CROP DISTRICTS IN 1975[1]

Crop District	Rapeseed	Rye
	------------bushels----------	
1	833,921	252,092
2	983,746	297,383
3	1,752,190	529,682
4	187,779	56,765
5	940,151	284,205
6	809,975	24,476
7	648,989	191,187
8	601,972	181,974
9	467,175	141,226
10	861,107	260,310
11	588,764	177,982
12	238,953	72,235
13	340,047	102,795
14	266,370	80,523

[1] Normal production of rapeseed and rye for each crop was determined by applying the formula given in the third step. See data in Table 2, Appendix C.

$$\hat{Y}_{ik} = \frac{\hat{Y}_{wi}}{\hat{Y}_m} \hat{Y}_{mk} \quad , \qquad (k=5, 6, \ldots 9)$$

Where:

$\hat{Y}_{ik}$ = The projected production of the k-th crop (i.e., rye or rapeseed) in the i-th crop district for 1975,

$\hat{Y}_{wi}$ = The projected production of wheat for the i-the crop district for 1975,

$\hat{Y}_m$ = The projected production of wheat for Manitoba for 1975,

$\hat{Y}_{mk}$ = The projected production for the k-th crop (rye or rapeseed) for Manitoba for 1975.

Finally, maximum and minimum level of production restraint for rye and rapeseed for each crop district were arrived at by using the following formula:

$$MAXP_{ki} = \frac{MAXW_i}{\hat{Y}_{wi}} \cdot \hat{Y}_{ik}, \qquad (k=5,6)$$

Where:

$MAXP_{ki}$ = The maximum production level of crop k (i.e. rye or rapeseed) over 1962-1975 in region i,

$MAXW_i$ = The maximum production level of wheat in the i-th crop district over 1962-75,

$\hat{Y}_{wi}$ = as defined earlier,

$\hat{Y}_{ik}$ = as defined earlier.

By following similar steps, one can establish the minimum production restraints for rye and rapeseed for each crop district. The maximum and minimum level of production of these crops is given in Table 8.

TABLE 8

ESTIMATED MAXIMUM AND MINIMUM PRODUCTION OF RYE AND RAPESEED IN DIFFERENT CROP DISTRICTS OF MANITOBA[1]

Crop District	Rye		Rapeseed	
	Maximum	Minimum	Maximum	Minimum
	thousands of bushels			
1	372.285	123.002	1231.520	406.892
2	472.594	167.295	1563.344	553.412
3	769.615	242.643	2545.889	802.663
4	100.814	27.945	333.493	92.444
5	350.558	109.765	1159.649	363.103
6	36.640	9.874	1212.529	326.771
7	259.269	101.562	880.093	344.753
8	296.012	94.594	979.210	312.919
9	255.670	75.432	845.757	249.529
10	497.178	146.031	1644.667	483.071
11	332.825	82.450	1100.984	272.744
12	102.663	20.339	339.610	67.283
13	170.825	34.627	565.088	114.547
14	125.103	30.005	413.842	99.255

[1]Minimum level of production of rye and rapeseed for each crop district was determined by applying the formula as discussed in Text·Similar formula was used in estimating the minimum levels of production of these crops at the crop district levels. Data used was taken from : Department of Agriculture, Yearbook of Manitoba Agriculture, Queen's Printers, 1960-74.

Production of sunflowers, sugarbeets and potatoes was constrained to specific crop districts as these crops were not grown in some crop districts in 1976. Sunflowers production was allowed in crop district 1-5, 7, 8, 11, and 13. Sugarbeets production was constrained to crop districts 2-5 and 9-11. Potatoes were grown in all crop districts with the exception of crop district 1, 5, 6, 13 and 14. The normal production of these crops as shown in Table 9 was determined for Manitoba in order to allocate this production to different crop districts according to the proportionate share of each crop sown in different crop districts in 1976.[76] Maximum and minimum production restraints as depicted in Table 11 were arrived at by increasing or decreasing the normal production in each crop district by an amount equal to the percentage increase or decrease of the actual maximum or minimum production over the normal production (Table 10) of each crop for Manitoba over the period 1962-75.

Minimum Feed Demand Constraints for Crop Districts

Minimum demand constraints for metabolizable energy for each crop district were established by using the following formula:

$$MER_i = \sum_{s=1}^{3} NREQ_s \times AU_i \times MEAB_s,$$

Where:

MER_i = Metabolized energy required for livestock in the i-th crop district,

$NREQ_s$ = Normal requirement per animal unit for the s-th commodity in bushels,

AU_i = Animal units in the i-th crop district,

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[76]See Appendix C Table 3.

TABLE 9

NORMAL PRODUCTION OF SUNFLOWERS, POTATOES AND SUGARBEETS IN 1975 AND PERCENT INCREASE OR DECREASE OF ACTUAL PRODUCTION OVER 1962-75 OVER NORMAL PRODUCTION

Crop	Normal Production	Percent Increase of Actual Maximum Production Over Normal Production (Percent)	Percent Decrease of Actual Minimum Production Under Normal Production (Percent)
Sunflower	90,897,950[a]	67.21	83.10
Potatoes	7,758,400[b]	5.27	55.34
Sugarbeets	329,683[c]	20.18	40.33

[a]in pounds

[b]in bushels

[c]in tons

[1]Normal production was determined by projecting the data from 1962 to 1975. Data was taken from Manitoba Department of Agriculture, Yearbook of Manitoba Agriculture, Queen's Printer, Winnipeg, 1976.

TABLE 10.

NORMAL PRODUCTION OF SUGARBEETS, SUNFLOWERS AND POTATOES IN DIFFERENT CROP DISTRICTS IN 1976[1]

Crop District	Sunflowers	Potatoes	Sugarbeets
	(000 pounds)	(000 bushels)	(Tons)
1	5,418	--	--
2	37,008	3,134	228,800
3	2,118	67	43,782
4	4,000	470	38,045
5	7,300	--	--
6	--	--	--
7	18,008	1,259	--
8	14,609	2,180	--
9	--	154	6,462
10	--	267	9,594
11	636	200	3,000
12	--	26	--
13	1,809	--	--
14	--	--	--
Manitoba	90,906	7,758	329,683

[1] Normal production of these crops for each crop district was determined by allocating the normal Manitoba production of these crops according to the proportionate share of the area sown in each crop district in 1976. Area sown to each crop in various crop district was obtained from Statistics Canada, Census of Canada, Agriculture, 1976.

TABLE 11

MAXIMUM AND MINIMUM PRODUCTION
OF SUNFLOWERS, SUGARBEETS AND POTATOES[1]

ID District	Sunflowers Maximum	Sunflowers Minimum	Potatoes Maximum	Potatoes Minimum	Sugarbeets Maximum	Sugarbeets Minimum
	(000 pounds)		(000 bushels)		(Tons)	
1	9,059	916	--	--	--	--
2	61,881	6,254	3,299	1,400	247,972	136,524
3	3,542	358	71	30	52,617	26,124
4	6,688	676	495	210	45,722	22,701
5	12,206	1,234	--	--	--	--
6	--	--	--	--	--	--
7	30,111	3,043	1,325	562	--	--
8	24,428	2,469	2,295	974	--	--
9	--	--	162	69	7,766	3,856
10	--	--	281	119	11,530	5,725
11	1,063	107	211	89	3,605	1,790
12	--	--	27	12	--	--
13	3,024	306	--	--	--	--
14	--	--	--	--	--	--
	152,002	15,363	8,166	3,495	396,212	196,720

[1]Maximum and minimum production of these crops in each crop district was obtained by increasing or decreasing the normal production given in Table 10 by the percent increase or decrease of actual production over 1962-75 over normal production as shown in Table 9.

$MEAB_s$ = Metabolized energy provided per bushel of commodity s,

s = 1 - wheat, s = 2 - oats, s = 3 - barley.

Normal requirement per animal unit for each commodity was determined by using the data for Canada as the feed data were not available for Manitoba. The following steps were involved in finding the values of MER_i.

1. Total annual requirements for wheat, oats and barley as feed were projected to 1976 by using the following equation:

$$FED_{st} = a_s + b_s X_t,$$

Where:

FED_{st} = Use of s-th commodity as feed in year t in Canada

s = 1 - wheat, s = 2 - oats, s = 3 - barley,

a_s = Intercept of the equation for the s-th commodity,

b_s = Regression co-efficient indicating the annual change in feed use for the s-th commodity,

X_t = Trend variable such that $x_t = 1$ for 1960, $x_{t+1} = 2$ for 1961, ... , $x_{t+14} = 15$ for 1974.

The projected figures[77] are as in Table 12, while the data used are given in Appendix C, Table 4.

2. Total number of units of livestock of various categories for Canada were projected to 1976 by using data from various sources shown in Appendix C, Table 5. A linear equation of the following form was used for projection:[78]

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[77] Overall regressions and regression coefficients were significant for these crops.

[78] Overall regression equations and regression coefficients were highly significant for various kinds of animals with the exception of bulls.

TABLE 12

PROJECTED USE OF CROPS AS FEED IN CANADA IN 1976[1]

Crop	Quantity in Bushels
Wheat	81,141,450
Oats	285,602,470
Barley	327,133,700

[1]Use of crops as feed was projected to 1976 by using the data from Statistics Canada, Grain Trade of Canada, cat. no. 22-201, 1966-75.

$$ANL_{it} = a_i + b_i X_t,$$

Where:

ANL_{it} = Number of animals of i-th kind in year t in Canada, i = 1 - bulls, i = 2 - milk cows, i = 3 - beef cows, i = 4 - dairy yearling heifers, i = 5 - beef yearling heifers, i = 6 - steers, i = 7 - calves, i = 8 - hogs, i = 9 - sheep and lamb, i = 10 - horses, i = 11 - hens and pullets,

a_i = Intercept of the equation for the k-th kind of animals,

b_i = Regression coefficient showing the annual change in number of animals of i-th kind,

x_t = 1 for 1963, x_{t+1} = 2 for 1964, ... , x_{t+12} = 13 for 1975.

The projected figures for sheep and lambs were divided into sheep units and lamb units on the basis of total number of these animals in Manitoba in 1974. Similarly, the projected number of hogs were further divided into pigs over six months and pigs under six months on the basis of total number of hogs in Manitoba in 1975. These animal numbers were divided into two categories in order to apply the appropriate conversion factors. The projected number of animals of various categories are depicted in Table 13.

3. Different kinds of animals are fed various levels of nutrient. Therefore projected number of animals in Canada were translated into units of animals by using the conversion factors or weights shown in Table 14.

TABLE 13

PROJECTED NUMBER OF ANIMALS IN CANADA IN 1976[1]

Category of Animal	Number
Bulls	260,255
Milk Cows	1,965,160
Beef Cows	4,245,874
Dairy yearling	482,206
Beef Yearling	1,466,276
Steers	1,862,455
Calves	4,071,678
Horses	266,085
Chickens	4,563,214
Pigs (6 months & older)	1,602,364
Pigs (under 6 months)	5,519,255
Sheep	290,085
Lamb	212,729

[1]Projected figures were obtained by using the data given in Appendix C, Table 5.

TABLE 14

FACTORS FOR CONVERSION OF VARIOUS LIVESTOCK INTO ANIMAL UNITS

Category of Animal	Animal Units
Beef Cow	0.80
Beef heifer & Steer	0.71
Bull	0.95
Pig over 6 mos.	0.44
Pig under 6 mos.	0.22
Sheep	0.13
Lamb	0.03
Chicken	0.005
Calves	0.64
Dairy cow	1.00
Dairy heifer	0.75
Horse	0.62

Source: Surendra N. Kulshreshtha. Prospects for Livestock Feedgrains Economy and Prairie Producers, Dept. of Agricultural Economics, University of Saskatchewan. Production Outlook 864, publication No. 225, Jan.-Feb., 1975, p. 13.

4. Normal requirements of feed per animal unit were determined by dividing the projected feed requirements of wheat, oats and barley by the total number of animal units in Canada. These are as shown in Table 15.

5. For each crop district total number of animals of various categories were estimated to 1976 by taking data from the Manitoba Yearbook[79] and using linear equation as used for projecting the number of animals for Canada. The projected number of animals of each category in each crop district are shown in Table 16.[80] Animal units were formed by using conversion factors already given.

6. Normal requirements for each crop district were determined by multiplying the requirement per animal unit by the number of animal units.

7. In order to allow the substitution of metabolizable energy coming from wheat, oats and barley, the normal feed requirements were converted to MCAL from these crops for each crop district by multiplying the metabolizable energy available from one bushel of each of these commodities.[81] The total metabolized energy required for livestock for each crop district is given in Table 17.

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[79]See Appendix C, Table 6-20.

[80]About 77 percent of the regression equations and regression coefficients were significant.

[81]Metabolized energy provided by one pound of wheat = 1.29 MCAL, one pound of oats = 1.11 MCAL, one pound of barley = 1.22 MCAL. See Faculty of Agriculture. Principles and Practices of Commercial Farming, University of Manitoba.

TABLE 15

CONSUMPTION OF DIFFERENT FEED GRAINS

PER ANIMAL UNIT IN CANADA[1]

Crop	Consumption in Bushels Per Animal Unit Per Year
Wheat	6.277
Oats	22.095
Barley	25.308

[1]Calculated by dividing the projected use of crops as feed by the projected number of animal units for Canada for 1976.

TABLE 16

PROJECTED NUMBERS OF ANIMALS OF VARIOUS CATEGORIES IN DIFFERENT CROP DISTRICTS[1]

Crop District	Bulls	Milk Cows & Heifers Over 2 Yr.	Beef Cows & Heifers Over 2 Yr.	Milk Heifers 1-2 Years	Beef Heifers 1-2 Years	Steers	Calves	Hogs 6 Months And Older	Hogs Under 6 Months	Sheep Over 1 Year	Sheep Under 1 Year	Chickens	Animal Units
1	1,654	2,150	35,838	288	8,923	13,815	32,715	5,288	24,652	204	369	44,516	78,540
2	1,877	4,704	39,381	750	11,654	17,765	33,912	33,230	102,377	50	--	177,102	119,182
3	1,419	11,146	22,750	2,850	8,446	15,296	23,988	44,679	153,828	2,265	1,303	1,294,210	125,346
4	515	6,777	13,315	1,612	4,562	6,531	12,273	10,159	42,835	1,108	773	111,340	49,476
5	1,465	21,031	17,381	7,123	7,442	13,127	22,969	44,893	155,118	1,619	1,208	1,611,077	133,155
6	754	4,050	11,608	688	3,623	3,796	10,935	3,985	12,866	150	69	242,114	32,651
7	2,058	2,088	41,112	4,435	13,881	14,342	34,581	13,240	31,359	915	838	75,422	95,675
8	1,742	5,146	30,385	1,508	9,888	18,165	29,212	15,040	56,149	2,081	1,308	207,409	91,170
9	1,154	3,673	30,481	423	5,623	9,604	22,985	13,286	59,225	323	31	183,591	74,829
10	2,700	4,958	47,742	427	12,050	14,223	38,796	12,918	38,735	923	762	39,391	104,065
11	2,184	3,112	40,692	--	11,508	10,642	34,285	9,950	46,298	1,923	1,492	48,625	90,510
12	2,365	7,742	60,677	1,746	14,865	15,346	49,727	8,905	24,931	685	519	172,411	123,424
13	573	842	13,462	127	4,531	6,215	11,073	13,684	37,469	--	--	15,337	41,308
14	1,938	2,619	51,704	--	11,042	8,285	39,089	6,465	17,240	3,500	1,988	35,607	91,892

[1]Data used for projection are taken from Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Queen's Printer, Winnipeg, 1963-75.

TABLE 17

METABOLIZABLE ENERGY REQUIRED IN DIFFERENT CROP DISTRICTS[1]

Crop District	Wheat	Oats	Barley	Total
	-------------------MCAL----------------------			
1	38,157,560	65,491,360	116,398,300	220,047,200
2	57,903,150	99,381,420	176,631,400	333,915,900
3	60,898,080	104,521,600	185,767,200	351,186,900
4	24,037,180	41,255,930	73,324,540	138,617,600
5	64,691,840	111,033,000	197,340,000	373,064,700
6	15,862,970	27,226,240	48,389,400	91,478,600
7	46,482,560	79,779,790	141,793,300	268,055,600
8	44,294,080	76,023,640	135,117,400	255,435,200
9	36,354,840	62,397,240	110,899,100	209,651,200
10	50,559,050	86,776,440	154,228,500	291,564,000
11	43,973,580	75,473,500	134,139,700	253,586,800
12	59,993,580	102,965,500	183,008,300	345,967,300
13	20,069,260	34,445,630	61,220,480	115,735,300
14	44,644,920	76,625,740	136,187,500	257,458,200

[1]Calculated by using the procedure discussed under minimum feed demand constraints.

Minimum Provincial Demand Constraint

Minimum provincial demand constraints were established by adding the human food demand, industrial demand and export demand to the livestock requirement for Manitoba. Expressed in equation form the relationship was

$$D_k = P_H b_{HK} + L_K + I_K + E_K ,$$

Where:

D_k = Demand for the k-th commodity for the province,

P_H = Human population in Manitoba,

b_{HK}= Per capita human consumption for the k-th commodity,

L_K = Livestock requirement for Manitoba,

I_k = Industrial normal requirement for the k-th commodity for Manitoba,

E_k = Normal export requirement for the k-th commodity for Manitoba.

Human food demand.[82] The method used for estimating human requirement involved the following steps.

(i) Total consumption of each commodity was projected[83] for 1976 for Canada by using the following equation and data from Grain Trade of Canada presented in Appendix C, Table 21.

$$P_{kt} = a_k + b_k T_t \quad (k=1, 2, 3, 5, 6),$$

P_{kt} = Total consumption of commodity k for period t,

k = 1 - wheat, k = 2 - oats, k = 3 - barley, k = 4 - flaxseed,

k = 5 - rye,

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[82] Food uses as estimated by Grain Trade of Canada are as follows: wheat-wheat flour and breakfast food; barley--pot and pearl barley and and breakfast foods; rye--rye flour and breakfast foods; and flaxseed--breakfast foods.

[83] Overall regressions and regression coefficients were significant for all crops.

a_k = Intercept for commodity k,

b_k = Regression coefficient showing the annual change in the consumption of commodity k,

T_t = Trend variable such that

$T_t = 1$ for 1962,

$T_t + 1 = 2$ for 1963,

$T_t + 13 = 14$ for 1975.

(ii) Total projected consumption shown in Table 18 for 1976 was divided by the Canadian population (i.e. 23,086,100)[84] to determine the per capita consumption.

(iii) Per capita consumption also shown in Table 18 was multiplied by the Manitoba population of 1,011,900[85] to determine the human food demand for Manitoba.

Industrial demand.[86] It was assumed that industrial demand for oats is zero, because oats have not been used for industrial purposes since 1961.

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[84] Statistics Canada, Population Projections for Canada and Provinces 1972-2001, Cat. No. 91-514, p. 61.

[85] Ibid., p. 61.

[86] Industrial uses as estimated by Grain Trade of Canada are as follows: wheat--distilling and alcohol industries; wheat flour--feed, starch adhesives, miscellaneous chemicals, explosives and pulp and paper industries; barley--malting and brewing; flaxseed and rapeseed for crushing includes seed crushed for subsequent export as oil and oil meals; rye-distilling.

TABLE 18

TOTAL PROJECTED HUMAN CONSUMPTION AND PER CAPITA CONSUMPTION OF DIFFERENT COMMODITIES IN CANADA[1]

Name of Commodity	Total Consumption	Per Capita Consumption
Wheat	69,752,200	3.0213938
Oats	4,312,830	0.1868150
Barley	102,162	0.00442526
Rye	524,627	0.02272479
Flaxseed	1,650.77	0.00007150

[1]Data used for projecting total human consumption are given in Table 21, Appendix C.

Following steps were followed in calculating the industrial demand for other commodities.

(i) Total industrial demand for Canada for each commodity was projected[87] to 1976 using data from Grain Trade of Canada for Canada.[88] The projected figures are given in Table 19.

(ii) Total production of each commodity for Canada was projected to 1976. The results are shown on Table 20. The data are given in Table 23 of the Appendix C.

(iii) Industrial demand projected for 1976 as percent of total projected production was calculated.

(iv) It was assumed that the industrial demand for each commodity for each crop district was a constant proportion of total production equivalent to the percent of total production used for industrial purposes for Canada.

Export demand. Export demand was calculated by following the identical procedure used for industrial demand. Export data are given in Appendix C, Table 24; while the projected figures for Canada are given in Table 21.

Livestock demand. Normal demand for livestock for Manitoba in terms of commodities as discussed already was used in this study. Total

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[87] Regression equations and regression coefficients were significant for wheat, barley, flaxseed and rapeseed, and nonsignificant for rye.

[88] See Appendix C, Table 22.

TABLE 19

PROJECTED INDUSTRIAL DEMAND FOR DIFFERENT COMMODITIES IN CANADA IN 1976[1]

Crop	Industrial Demand for 1976 bushels
Wheat	396,973.4
Barley	16,925,383
Rye	3,800,705
Flaxseed	1,982,496
Rapeseed	17,539,060

[1]Data used are given in Table 22, Appendix C.

TABLE 20

PROJECTED PRODUCTION OF DIFFERENT CROPS IN CANADA IN 1976[1]

Name of Crop	Production Bushels
Wheat	563,359,030
Oats	288,343,410
Barley	570,972,100
Flaxseed	23,524,545
Rapeseed	80,105,520
Rye	19,554,007

[1]Data used for projecting total productions of various commodities are given in Table 23, Appendix C.

TABLE 21

PROJECTED EXPORT OF DIFFERENT CROPS IN CANADA IN 1976[1]

Name of Crop	Quantity Exported
	-----bushels-----
Wheat	460,584,600
Oats	3,286,071
Barley	186,034,950
Rye	7,494,119
Flaxseed	19,140,899
Rapeseed	52,475,900

[1]See data in Appendix C, Table 24.

demand, arrived at by adding the four components of demand for different commodities, is given in Table 22.

Minimum quantity of sunflowers, potatoes and sugarbeets demanded for the province, was set at the minimum level of production of those commodities over 1962-75.

COST OF PRODUCTION

Cost of production of all crops for 1976 was based on the study conducted by Framingham et al.[89] They have reported the different components of total cost of production per acre of different commodities according to soil type and farm size for each crop district. Cost estimates were made specific for identified components of each crop reported by large size for 1976.

The total cost of production of each crop is reported under eight components by Framingham et al.[90] : labor, machinery, fertilizer, chemicals, seed cleaning and treatment, investment in land and buildings, taxes, and overhead. Since the authors have reported per acre cost of production for 1971, adjustments were made to arrive at costs for 1976. The method used for adjustments for each component is outlined below.

Labor

It was assumed that labor requirements per acre for different crops were the same in 1976 as in 1971 for large farms (760 acres and over). Adjustment was made for the change in wage rates by applying

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[89] Framingham, Craddock and Baker, *op. cit.*

[90] Ibid.

TABLE 22

VARIOUS TYPES OF DEMAND
FOR COMMODITIES IN MANITOBA [1]

Crop	Human Food	Industrial Demand	Export Demand	Livestock Demand	Total
	------------------------	--------	bushels ---	------------------------	
Wheat	3,057,348	45,888	53,595,151	7,854,300	64,552,687
Oats	189,038	--	579,770	27,647,086	28,415,894
Barley	4,478	2,464,074	25,512,300	31,667,450	59,648,302
Flax	72	616,409	2,801,996	--	3,418,477
Rapeseed	--	2,142,481	6,411,785	--	8,554,266
Rye	22,995	509,798	1,005,304	--	1,538,097

[1]The procedure used is discussed on page .

the following formula for each crop in each crop district.[91]

$$LAB_{ijk}^{1976} = LAB_{ijk}^{1971} \times \frac{LIN^{1976}}{LIN^{1971}},$$

Where:

LAB_{ijk}^{1976} = Labor cost for the k-th commodity in the i-th region for j-th soil in 1976,

LAB_{ijk}^{1971} = Labor cost for the k-th commodity in the i-th region for the j-th soil in 1971,

LIN^{1976} = The hired labor wage index for 1976,

LIN^{1971} = The hired labor wage index for 1971.

Machinery

Like labor, it was assumed that the machinery requirements per acre for different crops in different crop districts for two types of soils were the same in 1976 and 1971. A machinery price index[92] was used to determine the cost for 1976.

Fertilizer

It was assumed that efficient farm firms apply fertilizer at optimum levels. Average recommended levels of fertilizer given in "Field Crop Recommendations for Manitoba" for different crops grown on stubbles were used as given in Table 23. This was done because the

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[91] For hired wage price index see Statistics Canada, Farm Input Price Index, Catalogue No. 62-004, March 1977 and May 1972.

[92] Ibid.

TABLE 23

ACTUAL AND AVERAGE NITROGEN AND PHOSPHATE RECOMMENDATIONS FOR VARIOUS CROPS GROWN ON STUBBLE

Crop	Nitrogen		Phosphate	
	Actual[a]	Recommended[b]	Actual[a]	Recommended[b]
	pounds			
Wheat	28.45	50	25.75	25
Oats	26.35	50	21.59	25
Barley	34.62	50	24.82	25
Flaxseed	32.75	50	20.60	--
Rapeseed	37.27	50	23.99	25
Rye	20.01	75	23.17	10
Sunflower	43.38	50	26.21	25
Potatoes	n/a	50	n/a	40
Sugarbeet	n/a	75	n/a	60

[a]Calculated from Manitoba Crop Insurance Data

[b]Manitoba Department of Agriculture, Field Crop Recommendations for Manitoba, 1976.

n/a not available

Manitoba Crop Insurance Corporation data collected by the Department of agricultural economics, University of Manitoba, indicated that almost 100 percent of each crop was sown on stubble and the area sown on summer-fallow was negligible in 1976. These levels of fertilizer were assumed to be the same on both types of soils except that potash fertilizer was also applied on sandy soils as it was recommended in "Field Crop Recommendations."[93]

The levels of fertilizer obtained were multiplied by the price per pound of each type of fertilizer to get the cost per acre for each crop for both clay and sandy soils.

Chemicals

Recommended levels of herbicide and cost per acre were obtained from the Farm Data Handbook 974.[94] It was assumed that the rate of application per acre was the same in 1976 as it was in 1974. The cost reported per acre was adjusted by using the appropriate price index.

Seed Cleaning and Treatment Cost

Cost per bushel of cleaning and cost per bushel of treatment used in this study are given in Table 26. The cost of seed for sunflowers, potatoes and sugarbeets was also included in their respective total production cost as these seeds are normally purchased by farmers. The seed requirement per acre of other crops were deducted from their yields.

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[93]See Table 24.

[94]See Table 25.

TABLE 24

RECOMMENDED LEVEL OF POTASH (K_2O) ON SANDY SOILS

Crop	Actual[a]	Potash Recommended[b]
	------pounds------	
Wheat	8.75	22.50
Oats	7.90	22.5
Barley	9.03	22.50
Flax	7.74	45.00
Rye	3.47	22.50
Rapeseed	0.00	45.00
Sunflower	16.33	30.00
Potatoes	n/a	45.00
Sugarbeet	n/a	45.00

[a]Calculated from Manitoba Crop Insurance Data.

[b]Manitoba Department of Agriculture Field Crop Recommendations for Manitoba, 1976.

n/a not available

TABLE 25

RECOMMENDED HERBICIDES AND THEIR COST

Crop	Herbicide	Cost in 1972	Cost in 1976
		- - - - - - dollars	- - - - -
Wheat	MCPA	0.62	0.98
Oats	MCPA	0.62	0.98
Barley	MCPA	0.62	0.98
Flax	MCPA	0.53	0.84
Rye	MCPA	0.62	0.98
Rapeseed	Treflen	4.90	7.75
Sugarbeet	Avadex BW	6.46	10.21
Sunflower	Treflen	4.90	7.75
Potatoes	Eptam	13.00	20.56

Source, Manitoba Department of Agriculture, Farm Data Handbook, Economics Branch, II 9, 1972.

TABLE 26

SEED CLEANING AND TREATMENT COST
FOR DIFFERENT CROPS

Name of Crop	Seed Cleaning[a] Cost/Bushel ¢	Seed Treatment[b] Cost/Bushel ¢	Seeding Rate Per Acre[c] Bushels	Total Cost Per Acre ¢
Wheat	5.5	40	1.50	68
Oats	5.0	-	2.30	12
Barley	5.375	40	1.60	73
Flax	6.0	-	0.60	4
Rye	5.125	-	1.20	6
Rapeseed	5.375	8.00	0.15	1.21

[a]Seed cleaning cost for 1976 was obtained from George McLaughlin, Canada Grain Commission.

[b]Discussion with A. Martin, Manitoba Department of Agriculture indicated that seed treatment is recommended only for wheat, barley and rapeseed. Cost per bushel of treatment was obtained from Hoffer A. Jack, Uniroyal Chemical Limited, while the cost for rapeseed was obtained from Chipman Chemicals Limited.

[c]See Framingham, Craddock and Baker op. cit.

Investment in Land and Building

Land is treated as a type of capital which could be leased, bought or sold in the market.[95] Return on the capital value of investment in land is considered as cost in this study. The annual cost of land and buildings for crop production was calculated by **multiplying** an interest rate of nine percent[96] times the projected value of farm land per acre as shown in Table 27 for 1976 by using the data given in Table 11 of the Appendix C.

Overhead

Overhead costs exclusive of house expenses were defined as the sum of hydro, telephone, taxes on land and buildings, fire insurance and miscellaneous expenses such as bank charges.[97] Overhead cost for 1976 was determined by using the total farm input price index for 1976 and 1971 along with the cost reported per acre for different crops by Framingham et al.[98]

$$OHC_k^{1976} = OHC_k^{1971} \times \frac{FII^{1976}}{FII^{1971}},$$

Where:

OHC_k^{1976} = Overhead cost per acre for crop k in year 1976,

OHC^{1971} = Overhead cost per acre for crop k in year 1971,

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[95] See Raleigh Barlowe, Land Resource Economics, The Economics of Real Property, Second Edition, Prentice Hall, Inc., Englewood Cliffs, N.J., 1972, p. 172.

[96] Information obtained from the Agricultural Credit Corporation Office.

[97] C.F. Framingham, W.J. Craddock, L.B.B. Baker, *op. cit.*

[98] Ibid.

TABLE 27

PROJECTED VALUE OF FARM LAND PER ACRE BY CROP DISTRICTS IN 1976[1]

Crop District	Value $/Acre
1	116.30
2	136.15
3	192.90
4	179.99
5	167.84
6	85.96
7	90.05
8	123.21
9	120.16
10	102.23
11	109.43
12	71.24
13	119.56
14	81.82

[1]Data used are given in Appendix C, Table 25.

FII^{1976} = Total farm input price index for 1976,

FII^{1971} = Total farm input price for 1971.

Taxes

Tax cost was determined by using the property tax index. The procedure applied using the Framingham et al[99] study data was similar to that for overhead.

Total cost of production in various crop districts arrived at by using the above procedure for different crops on various soil types is given in Table 28.

YIELD ESTIMATION

It was assumed that fertilizers were applied at recommended rates. Therefore, the average yields obtained in Manitoba with recommended levels of fertilizers over the period 1966-74 were used in the study. It was assumed that the yields per acre were the same on both types of soils.[100] Yields for Manitoba for 1976 at the recommended levels of fertilizer were obtained by applying the following formula:

$$Y^{1976} = \frac{NY_{km}^{1976}}{AY_{km}} \times YRF_k ,$$

[99] Ibid.

[100] Discussion with R.A. Hedlin, Professor and Head, Soil Science Dept. and with K.M. McGill, Director, Soil Testing Laboratory, University of Manitoba, indicated that yield per acre of different crops is the same for both types of soil. However, they suggested that potash at the recommended level would be used on sandy soil which is not required on clay soil.

TABLE 28

COST OF PRODUCTION PER ACRE OF DIFFERENT CROPS[1]

Crop District	Soil Type	Wheat	Oats	Barley	Flax	Rapeseed	Rye	Sunflower	Potatoes	Sugarbeet
		$ per acre								
1	1	49.75	50.12	49.26	45.34	59.16	48.58	58.60	--	--
	2	48.31	48.49	47.56	42.88	56.21	47.06	58.60	--	--
2	1	50.92	50.97	50.19	45.80	60.05	49.29	60.08	245.70	283.42
	2	49.56	49.35	48.52	43.32	57.12	47.79	60.08	245.70	283.42
3	1	56.43	56.76	55.87	52.63	66.57	55.24	64.30	249.92	287.65
	2	54.40	54.70	53.80	48.42	62.32	53.20	64.30	249.92	287.65
4	1	55.24	54.41	53.74	49.80	64.61	52.98	62.55	248.17	285.89
	2	53.23	52.35	51.70	45.57	60.37	50.95	62.55	248.17	285.89
5	1	55.97	55.44	55.39	51.90	65.96	54.62	63.48	--	--
	2	53.95	53.38	53.36	47.70	61.71	52.58	63.48	--	--
6	1	51.51	50.77	51.13	44.96	60.56	49.82	--	--	--
	2	49.02	48.03	48.51	43.26	57.46	47.33	--	--	--
7	1	48.33	48.56	47.91	43.66	57.89	47.36	57.42	243.04	--
	2	46.94	46.96	46.25	41.20	54.91	45.96	57.42	243.04	--
8	1	49.80	50.08	49.22	45.64	59.20	48.18	59.07	244.69	--
	2	48.44	48.49	47.57	43.19	56.31	46.74	59.07	244.69	--
9	1	50.19	50.24	49.43	46.00	59.54	48.65	--	244.46	282.18
	2	48.83	48.62	47.82	43.53	56.58	47.18	--	244.46	282.18
10	1	50.03	51.08	49.99	45.54	59.62	48.76	--	243.53	281.25
	2	48.60	49.49	48.32	43.05	56.62	47.26	--	243.53	281.25
11	1	50.27	50.79	50.09	46.15	60.32	48.69	57.94	243.56	281.28
	2	49.07	48.14	47.37	42.20	54.47	46.47	57.94	243.56	281.28
12	1	50.43	49.79	50.30	43.77	59.26	48.85	--	240.73	--
	2	47.94	46.96	47.66	40.94	55.11	46.39	--	240.73	--
13	1	50.97	51.52	50.94	46.92	60.47	49.64	58.91	--	--
	2	49.81	48.49	48.70	43.38	54.66	47.61	58.91	--	--
14	1	50.78	49.58	49.34	45.72	59.11	49.46	--	--	--
	2	48.33	46.81	46.71	42.56	54.69	47.02	--	--	--

[1]Calculated by using the procedure discussed in Text.

Where:

Y^{1976}_{km} = Yield for k-th crop for Manitoba at the recommended level of fertilization in 1976,

NY^{1976}_{km} = Normal yield for Manitoba for k-th crop in 1976,

AY^{1976}_{km} = Average yield of the k-th crop over 1966-74,

YRF_k = Average yield for the k-th crop when recommended levels of fertilizers were applied over 1966-74.[101]

Normal yield for Manitoba for the k-th crop were obtained by using the following form of equation and the data in Appendix C, Table 26. The projected yields are given in Table 30.

$$Y_{kt} = a_k + b_k T_t ,$$

Where:

Y_{kt} = Yield of the k-th crop for the t-th period,

a_k = Intercept for the k-th crop,

b_k = Regression coefficient for the k-th crop,

T_t = Trend variable such that,

T_t = 1 for 1962,

T_{t+1} = 2 for 1963,

.

.

T_{t+12} = 13 for 1974,

Yield of different crops for each crop district was obtained by using the following formula:

$$Y^{1976}_{ik} = \frac{NY^{1976}_{ik}}{NY^{1976}_{k}} \times Y^{1976}_{km} ,$$

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[101]See Table 29.

TABLE 29

AVERAGE YIELD OF MAJOR CROPS IN MANITOBA
WHEN RECOMMENDED LEVELS OF FERTILIZERS WERE APPLIED
OVER 1966-74

Year	Wheat	Oats	Barley	Flax
	bushel per acre			
1966	27.0	53.5	36.6	10.9
1967	30.6	53.1	40.5	11.5
1968	34.7	72.1	48.6	16.5
1969	32.1	66.1	48.2	15.7
1970	26.5	54.4	42.6	15.2
1971	35.5	73.0	57.5	12.9
1972	32.2	64.2	50.9	14.5
1973	30.9	54.4	49.5	17.0
1974	31.2	61.4	46.8	14.3
Average	31.19	61.36	46.8	14.28

Source; Data for 1966-73 were taken from P.F. Fehr, "Soil Testing Report 1971-72 to 1973-74" in papers presented at the Eighteenth Annual Manitoba Soil Science Meeting, 1973, p. 117. 1974 data were obtained from K.S. Mcgill, Director, Soil Science Laboratory, University of Manitoba, Winnipeg.

TABLE 30

PROJECTED YIELD PER ACRE FOR DIFFERENT CROPS
IN MANITOBA IN 1976

Name of Crop	Projected Yield
	------bushel per ac.-----
Wheat	25.45
Oats	45.56
Barley	38.17
Flax	10.86
Rye	23.78
Rapeseed	18.52
Sunflower*	871.71
Sugarbeet**	11.19
Potatoes	230.37

* pounds

** tons

Where:

Y_{ik}^{1976} = Yield of the k-th crop in the i-th crop district in 1976,

NY_{ik}^{1976} = Normal yield for the k-th crop in the i-th crop district in 1976.[102] Data used are in Table 27 to 40 of the Appendix C,

Ny_{k}^{1976} = Normal yield for k-th crop for Manitoba in 1976,

Y_{km}^{1976} = Yield for the kth crop for Manitoba at the recommended level of fertilization in 1976.

Since the yield per acre for rye, rapeseed, sunflowers, sugarbeets and potatoes were not available for different crop districts over time, the following formula was used for determining the yield per acre for the various crop districts.

$$Q_{ik}^{1976} = \frac{QWH_i^{1976}}{QWH^{1976}} \; QM_k^{1976}, \qquad (k = 5, 6, \ldots 9)$$

Where:

Q_{ik}^{1976} = the yield per acre of the k-th crop (k = 5,6, . . . 9) in the i-th crop district for 1976 with recommended level of fertilizer,

QWH_i^{1976} = the yield per acre of wheat for the i-th crop district in 1976 with recommended level of fertilizer,

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[102]Projected normal yield of wheat, oats, barley and flax are given in Table 31. The results of overall regression equations and regression coefficients varied from nonsignificant to highly significant levels for these crops in different crop districts.

TABLE 31

PROJECTED YIELD OF WHEAT, OATS, BARLEY AND FLAX IN DIFFERENT CROP DISTRICTS IN 1976

Crop District	Wheat	Oats	Barley	Flax
	------------------bushel per acre-----------			
1	25.35	46.56	39.53	10.30
2	26.61	48.47	40.70	11.95
3	25.56	48.08	39.80	9.88
4	26.93	43.13	37.40	11.45
5	23.18	43.81	33.42	10.58
6	24.03	36.79	37.57	11.74
7	25.01	44.98	38.69	11.28
8	27.29	50.39	44.14	13.32
9	24.07	41.76	36.01	11.25
10	26.20	45.79	43.40	11.99
11	24.00	40.57	33.25	10.29
12	25.22	41.33	33.92	12.53
13	27.91	43.53	33.87	15.59
14	24.18	40.21	33.14	10.05

[1]Data used are given in Appendix C, Table 27 to 40.

QWH^{1976} = the projected yield per acre for wheat for Manitoba in 1976,

QM_k^{1976} = the projected yield for the k-th crop (k = 5, 6, . . . 9) for Manitoba for 1976.

From the projected yields, at the recommended levels of fertilizers shown in Table 32, the average seed requirements per acre (Table 26) were deducted to get the net yield for wheat, oats, barley, flax, rye and rapeseed.[103] Cost of seed of other crops was included in their cost of production and thus seed was not deducted from gross yield. Their yields are given in Table 34.

SELLING PRICES

Since at the time of making land allocation decisions, farmers do not know the price at which the crop will be sold, they commonly use the preceding year's price as a basis to allocate acreage among crops. So prices for 1974-75 for different commodities were used in this analysis as these were also the most recent available. Since there were a number of grades for each commodity, a number of prices prevailed for each crop. In order to arrive at a particular price for each crop, average percentage distribution of grades of each commodity for the period 1972-75 and their respective prices for 1974-75 were taken into account.[104] Different grades of various commodities constituted 63-97 percent of the total quantity of grain inspected in Western divisions.[105] An arithmetic mean of the resulting percentage

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[103] See Table 33.

[104] This procedure is identical to the one used by Framingham et al.

[105] See Table 35 and 36.

TABLE 32

YIELD PER ACRE OF DIFFERENT CROPS
IN VARIOUS CROP DISTRICTS
GIVEN RECOMMENDED LEVEL OF FERTILIZER USE[1]

...p District	Wheat	Oats	Barley	Flax	Rye	Rapeseed
	------------------bushel per acre------------------					
1	31.37	63.03	50.92	13.97	29.31	22.83
2	32.93	65.62	52.43	16.21	30.77	23.96
3	31.63	65.09	51.27	13.40	29.55	23.02
4	33.32	58.39	48.18	15.53	31.13	24.25
5	28.68	59.31	43.05	14.35	26.80	20.87
6	29.73	49.81	48.40	15.92	27.78	21.63
7	30.95	60.89	49.84	15.30	28.92	22.52
8	33.77	68.22	56.86	18.07	31.55	24.57
9	29.78	56.54	46.39	15.26	27.83	21.67
10	32.42	61.99	55.91	16.26	30.29	23.59
11	29.70	54.92	42.83	13.96	27.75	21.61
12	31.21	55.95	43.70	17.00	29.16	22.71
13	34.53	58.93	43.63	21.15	32.26	25.13
14	29.92	54.44	42.69	13.63	27.96	21.77

[1]Calculated by applying the formula given on page 104

TABLE 33

NET YIELD PER ACRE OF DIFFERENT CROPS IN VARIOUS CROP DISTRICTS[1]

Crop District	Wheat	Oats	Barley	Flax	Rye	Rapeseed
	------------------------		bushels	------------------------		
1	29.87	60.73	49.32	13.37	28.11	22.68
2	31.43	63.32	50.83	15.61	29.57	23.81
3	30.13	62.79	49.67	12.80	28.35	22.87
4	31.82	56.09	46.58	14.93	29.93	24.10
5	27.18	57.01	41.45	13.75	25.60	20.72
6	28.23	47.51	46.80	15.32	26.58	21.48
7	29.45	58.59	48.24	14.70	27.72	22.37
8	32.27	65.92	55.26	17.47	30.35	24.42
9	28.28	54.24	44.79	14.66	26.63	21.52
10	30.92	59.79	54.31	15.66	29.09	23.44
11	28.20	52.62	41.23	13.36	26.55	21.46
12	29.71	53.65	42.10	16.40	27.96	22.56
13	33.03	56.63	42.03	20.55	31.06	24.98
14	28.42	52.14	41.09	13.03	26.76	21.62

[1]Net yield per acre for these crops was determined by deducting the seed rate (Table 26) from gros yield (Table 32).

TABLE 34

YIELD PER ACRE OF SUNFLOWERS, POTATOES AND SUGARBEETS GIVEN RECOMMENDED LEVEL OF FERTILIZER USE[1]

Crop District	Sunflower (pounds)	Potatoes (bushels)	Sugarbeet (tons)
1	1074.48	--	--
2	1127.91	298.08	15.07
3	1083.39	286.31	14.48
4	1141.27	301.61	15.25
5	982.34	--	--
6	--	--	--
7	1060.10	280.16	--
8	1020.02	305.68	--
9	--	269.56	13.63
10	--	293.46	14.84
11	1017.28	268.84	13.59
12	--	282.51	--
13	1182.72	--	--
14	--	--	--

[1]Calculated by applying the formula given in page 107.

figures is depicted in Table 35 and 36 and the resulting total of different grades of each commodity is as follows:

Wheat:	Red Spring & Canada Utility	82.6%
	Durum	95.3%
Oats		72.5%
Barley		78.3%
Rye		94.5%
Flaxseed		95.7%
Rapeseed		96.0%

These percentages of different grades of each commodity were then expanded in order to reach 100%. The percentages were then multiplied with the respective prices in Table 37 and 38 in order to get the weighted price. The respective prices of different grades of different commodities were the total payment received by farmers basis in store Thunder Bay. In order to get the prices of various commodities in various crop district, freight rates per bushel and handling and storage cost from each crop district to Thuder Bay were deducted. Since the freight rates were the same in 1974-75 as they were in 1971-72, the freight rate used in this study are the same as were used by Framingham et al.[106] The resulting prices are given in Table 39 to 44. For sunflowers, potatoes and sugarbeets, prices were taken from the Manitoba Agriculture Yearbook[107] for 1975 and were:

Sunflower	$ .095	per pound
Potatoes	$2.33	per bushel
Sugarbeets	$35.00	per ton

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[106] Framingham, Craddock and Baker op. cit.

[107] Manitoba Department of Agriculture, op. cit., 1975

TABLE 35

WEIGHTED PRICES FOR WHEAT, OATS AND BARLEY

	1972-73	1973-74	1974-75	Average 1972-75	Weighted Percent	Realized Price 1974-75	Weighted Price 1974-75
	---Percent Distribution---					---$/Bushel---	
Wheat							
1 CW Redspring	65.13	58.16	31.29	51.527	28.960	4.47414	1.29571
2 CW Redspring	16.63	21.77	16.10	18.167	10.211	4.30624	0.43971
3 CW Redspring	8.46	3.93	14.52	8.97	5.041	4.26209	0.21485
1 Canada Utility	0.02	0.23	0.98	0.41	0.230	4.26941	0.00982
2 Canada Utility	0.01	0.02	0.30	0.11	0.063	4.26941	0.00269
3 Canada Utility	0.65	0.52	9.13	3.433	1.929	3.64768	0.07036
	90.90	84.63	72.32	82.617			
1 CW Amber Durum	6.57	6.85	5.63	6.53	3.569	6.23136	0.22240
2 CW Amber Durum	30.85	29.60	18.08	26.177	14.712	6.22136	0.91529
3 CW	31.11	32.14	19.02	27.423	15.413	6.16072	0.94955
Extra 4 CW Amber Durum	16.00	16.39	11.64	14.677	8.249	6.19136	0.51073
4 CW Amber Durum	11.12	10.32	23.04	14.827	8.333	6.13002	0.51081
5 CW Amber Durum	1.38	1.57	14.61	5.853	3.290	5.28985	0.17404
	97.03	96.87	92.02	95.307	100.000		5.31596
Oats							
1 CW	0.24	-	0.03	0.09	0.124	1.76752	0.00219
2 CW	1.44	0.31	0.04	0.60	0.827	1.76752	0.01462
Extra 3 CW	24.26	0.94	0.22	8.473	11.683	1.74252	0.20358
Extra 1 Feed	48.91	11.15	7.06	22.373	30.850	1.67517	0.51679
1 Feed	4.78	57.00	49.83	37.203	51.299	1.65517	0.84909
2 Feed	0.93	4.40	6.02	3.783	5.217	1.62517	0.08479
	80.56	73.80	63.20	72.522	100.000		1.67101
Barley							
1 CW Six-Row	0.32	0.22	0.02	0.187	0.239	3.26367	0.00780
2 CW Six-Row	10.77	10.86	5.82	9.15	11.692	3.24367	0.37925
1 CW Two-Row	0.23	0.30	0.04	0.19	0.243	3.24608	0.00789
1 Feed	65.41	57.55	55.49	59.483	76.006	2.33073	1.77149
2 Feed	5.33	6.39	12.92	8.213	10.495	2.31533	0.24299
3 Feed	0.49	0.72	1.90	1.037	1.325	2.25245	0.02984
	82.50	76.04	76.19	78.26	100.000		2.43926

TABLE 36

WEIGHTED PRICE FOR FLAXSEED, RAPESEED AND RYE

	1972-73	1973-74	1974-75	Average 1972-75	Weighted Percent	Realized Price 1974-75	Weighted Price 1974-75
	------Percent Distribution------					---$/Bushel---	
Flaxseed							
1 C.W.	95.67	95.76	83.07	91.50	95.631	9.54	9.12320
2 C.W.	1.71	1.59	6.21	3.17	3.313	9.41	0.31175
3 C.W.	0.67	0.75	1.61	1.01	1.056	8.10	0.08554
	98.05	98.10	90.89	95.68	100.000		9.52049
Rapeseed							
1 Canada	91.01	95.73	91.79	92.843	96.701	7.23	6.99148
2 Canada	3.46	2.16	4.88	3.167	3.299	7.07	0.23324
	93.47	97.89	96.67	96.010	100.00		7.22472
Rye							
2 C.W.	49.93	60.47	70.69	60.363	63.901	2.62	1.67421
3 C.W.	44.87	31.78	16.57	31.073	32.894	2.57	0.84538
4 C.W.	1.75	2.52	2.68	2.317	2.453	2.39	0.05863
Ergoty	1.35	0.71	0.07	0.71	0.752	2.34	0.01760
	97.90	95.48	90.01	94.463	100.00		2.59582

Source; Statistics Canada, Grain Trade of Canada, Cat. No. 22-201, 1972-75.

TABLE 37

TOTAL PAYMENTS RECEIVED BY PRODUCERS
FOR PRINCIPAL GRADES OF DIFFERENT CROPS
BASIS IN STORE THUNDERBAY OR VANCOUVER 1974-75

Grade	Total Payment $/Bushel
Wheat	
Red Spring Wheat Grades	
No. 1 Canada Western Red Spring	4.47414
No. 2 Canada Western Red Spring	4.30624
No. 3 Canada Western Red Spring	4.26209
No. 1 Canada Utility	4.26941
No. 2 Canada Utility	4.26941
No. 3 Canada Utility	3.64768
Amber Durum Wheat Grades	
No. 1 Canada Western Amber Durum	6.23136
No. 2 Canada Western Amber Durum	6.22136
No. 3 Canada Western Amber Durum	6.16072
Extra No. 4 Canada Western Amber Durum	6.19136
No. 4 Canada Western Amber Durum	6.13002
No. 5 Canada Western Amber Durum	5.28985
Oats	
No. 1 Canada Western	1.76752
No. 2 Canada Western	1.76752
Extra No. 3 Canada Western	1.74252
Extra No. 1 Feed	1.67517
No. 1 Feed	1.65517
No. 2 Feed	1.62517
Barley	
No. 1 Canada Western Six Row	3.26367
No. 2 Canada Western Six Row	3.24367
No. 2 Canada Western Two Row	3.24608
No. 1 Feed	2.33073
No. 2 Feed	2.31533
No. 3 Feed	2.25245

Source; The Canadian Wheat Board, Annual Report, 1974-75, pp. 55-57.

TABLE 38

WINNIPEG COMMODITY EXCHANGE CLOSING CASH PRICES FOR RYE, FLAXSEED AND RAPESEED BASIS IN STORE THUNDERBAY 1974-75

Grade	Price
	$/Bushel
Flaxseed	
1.C.W. - 1.O.C.	9.54
2.C.W. - 2.O.C.	9.41
3.C.W. - 3.O.C.	8.10
Rapeseed	
1 Canada	7.23
2 Canada	7.07
Rye	
2.C.W. - 2.O.C.	2.62
3.C.W. - 3.O.C.	2.57
4.C.W. - 4.O.C.	2.39
Ergoty	2.34

Source, Statistics Canada, Quarterly Bulletin of Agricultural Statistics, Cat. No. 21-003, 1974-75.

TABLE 39

REALIZED PRICE OF WHEAT BY CROP DISTRICT
AFTER DEDUCTING FREIGHT RATES,
HANDLING AND OTHER CHARGES

Crop District	Freight Rates[a] To ThunderBay $ per bushel	Handling and[b] Other Charges $ per bushel	Realized[c] Price $ per bushel
1	0.108	0.178	5.03
2	0.096	0.178	5.04
3	0.090	0.178	5.05
4	0.090	0.178	5.05
5	0.090	0.178	5.05
6	0.084	0.178	5.05
7	0.108	0.178	5.03
8	0.096	0.178	5.04
9	0.096	0.178	5.04
10	0.108	0.178	5.03
11	0.108	0.178	5.03
12	0.096	0.178	5.04
13	0.108	0.178	5.03
14	0.096	0.178	5.04

[a]Crows Nest Pass rates expressed in cents per 100 pounds, are converted here to dollars per bushel.

[b]Handling and other charges (i.e. custom cleaning, storage cost, etc.) for 1976 were obtained from George McLaughlin, Canadian Grain Commission, Winnipeg.

[c]Realized price is the price of wheat ($5.316 per bushel in Table 35) minus freight rates, handling and other charges.

TABLE 40

REALIZED PRICE OF OATS BY CROP DISTRICT
AFTER DEDUCTING FREIGHT RATES,
AND HANDLING AND OTHER CHARGES

Crop District	Freight Rates[a] To ThunderBay $ per bushel	Handling and[b] Other Charges $ per bushel	Realized[c] Price $ per bushel
1	0.061	0.110	1.50
2	0.055	0.110	1.51
3	0.051	0.110	1.51
4	0.051	0.110	1.51
5	0.051	0.110	1.51
6	0.048	0.110	1.51
7	0.061	0.110	1.50
8	0.054	0.110	1.51
9	0.054	0.110	1.51
10	0.061	0.110	1.50
11	0.061	0.110	1.50
12	0.054	0.110	1.51
13	0.061	0.110	1.50
14	0.054	0.110	1.51

[a]Crows Nest Pass rates expressed in cents per 100 pounds are converted here to dollars per bushel.

[b]Handling and other charges (i.e. custom cleaning, storage cost, etc.) for 1976 were obtained from George McLaughlin, Canadian Grain Commission, Winnipeg.

[c]Realized price is the price of oats ($1.671 per busnel in Table 35) minus freight rates, handling and other charges.

TABLE 41

REALIZED PRICE OF BARLEY BY CROP DISTRICT
AFTER DEDUCTING FREIGHT RATES,
HANDLING AND OTHER CHARGES

Crop District	Freight Rates[a] to ThunderBay $ per bushel	Handling and[b] Other Charges $ per bushel	Realized[c] Price $ per bushel
1	0.086	0.176	2.18
2	0.077	0.176	2.19
3	0.072	0.176	2.19
4	0.072	0.176	2.19
5	0.072	0.176	2.19
6	0.067	0.176	2.20
7	0.086	0.176	2.18
8	0.077	0.176	2.19
9	0.077	0.176	2.19
10	0.086	0.176	2.18
11	0.086	0.176	2.18
12	0.077	0.176	2.19
13	0.086	0.176	2.18
14	0.077	0.176	2.19

[a]Crows Nest Pass rates expressed in cents per 100 pounds are converted here to dollars per bushel.

[b]Handling and other charges (i.e. custom cleaning, storage costs, etc.) for 1976 were obtained from George McLaughlin, Canadian Grain Commission, Winnipeg.

[c]Realized price is the price of barley ($2.439 per bushel in Table 35) minus freight rates, handling and other charges.

TABLE 42

REALIZED PRICE OF FLAXSEED BY CROP DISTRICT
AFTER DEDUCTING FREIGHT RATES,
HANDLING AND OTHER CHARGES

Crop District	Freight Rates[a] to ThunderBay $ per bushel	Handling and[b] Other Charges $ per bushel	Realized[c] Price $ per bushel
1	0.109	0.256	9.16
2	0.098	0.256	9.17
3	0.092	0.256	9.17
4	0.092	0.256	9.17
5	0.092	0.256	9.17
6	0.092	0.256	9.17
7	0.109	0.256	9.16
8	0.098	0.256	9.17
9	0.098	0.256	9.17
10	0.109	0.256	9.16
11	0.109	0.256	9.16
12	0.098	0.256	9.17
13	0.109	0.256	9.16
14	0.098	0.256	9.17

[a]Crows Nest Pass rates expressed in cents per 100 pounds are converted here to dollars per bushel.

[b]Handling and other charges (i.e. custom cleaning, storage cost, etc.) for 1976 were obtained from George McLaughlin, Canadian Grain Commission, Winnipeg.

[c]Realized price is the price ($9.52 per bushel in Table 36) minus freight rates, handling and other charges.

TABLE 43

REALIZED PRICE OF RAPESEED BY CROP DISTRICT
AFTER DEDUCTING FREIGHT RATES,
HANDLING AND OTHER CHARGES

Crop District	Freight Rates[a] to ThunderBay $ per bushel	Handling and[b] Other Charges $ per bushel	Realized[c] Price $ per bushel
1	0.098	0.239	6.89
2	0.088	0.239	6.90
3	0.083	0.239	6.90
4	0.083	0.239	6.90
5	0.083	0.239	6.90
6	0.083	0.239	6.90
7	0.098	0.239	6.89
8	0.088	0.239	6.90
9	0.088	0.239	6.90
10	0.098	0.239	6.89
11	0.098	0.239	6.89
12	0.088	0.239	6.90
13	0.098	0.239	6.89
14	0.088	0.239	6.90

[a]Crows Nest Pass rates expressed in cents per 100 pounds are converted here to dollars per bushel.

[b]Handling and other charges (I.e. custom cleaning, storage cost, etc.) for 1976 were obtained from George McLauglin, Canadian Grain Commission, Winnipeg.

[c]Realized price is the price ($7.229 per bushel in Table 36) minus freight rates, handling and other charges.

TABLE 44

REALIZED PRICE OF RYE BY CROP DISTRICT
AFTER DEDUCTING FREIGHT RATES,
HANDLING AND OTHER CHARGES

p District	Freight Rates[a] to ThunderBay $ per bushel	Handling and[b] Other Charges $ per bushel	Realized[c] Price $ per bushel
1	0.101	0.174	2.32
2	0.090	0.174	2.33
3	0.084	0.174	2.34
4	0.084	0.174	2.34
5	0.084	0.174	2.34
6	0.084	0.174	2.34
7	0.101	0.174	2.32
8	0.090	0.174	2.33
9	0.090	0.174	2.33
10	0.101	0.174	2.32
11	0.101	0.174	2.32
12	0.090	0.174	2.33
13	0.100	0.174	2.32
14	0.090	0.174	2.33

[a]Crows Nest Pass rates expressed in cents per 100 pounds are converted here dollars per bushel.

[b]Handling and other charges (i.e. custom cleaning, storage cost, etc.) for 5 were obtained from George McLauglin, Canadian Grain Commission, Winnipeg.

[c]Realized price is the price ($2.596 per bushel in Table 36) minus freight es, handling and other charges.

NET INCOME

Given the yields, prices and cost of production of various crops on different soil types for each region, net income per acre was determined by deducting the cost of production from the gross income. 1976 net income per acre from sunflowers, potatoes, and sugarbeets is given in Appendix C, Tables 41 to 43 while the net income from other crops is depicted in Table 45. 1971 net income for all crops is shown in Appendix C, Table 44.

TABLE 45

NET INCOME PER ACRE FROM VARIOUS CROPS
ON DIFFERENT SOIL TYPES IN 1976

Crop District	Soil Type	Wheat	Rapeseed	Oats	Barley	Rye	Flax
		----------------	--------------$/acre	----------	----------	----------	----------
1	1	100.50	97.10	40.98	58.26	16.63	77.12
	2	101.93	100.06	42.60	59.96	18.15	79.59
2	1	107.49	104.24	44.64	61.13	19.61	97.35
	2	108.85	107.17	46.26	62.79	21.11	99.83
3	1	95.73	91.23	38.05	52.90	11.10	64.75
	2	97.75	95.48	40.11	54.97	13.14	68.95
4	1	105.45	101.68	30.29	48.27	17.06	87.11
	2	107.47	105.92	32.34	50.31	19.08	91.34
5	1	81.29	77.01	30.65	35.39	5.28	74.19
	2	83.31	81.26	32.71	37.41	7.33	78.39
6	1	91.06	87.65	20.97	51.83	12.38	95.52
	2	93.54	90.75	23.71	54.45	14.87	97.23
7	1	99.80	96.24	39.33	57.25	16.95	90.99
	2	101.19	99.22	40.92	58.91	18.35	93.45
8	1	112.84	109.29	49.46	71.90	21.84	114.56
	2	114.20	112.19	51.05	73.45	23.27	117.01
9	1	92.34	88.94	31.66	48.66	13.40	88.44
	2	93.70	91.91	33.28	50.27	14.87	90.90
10	1	105.49	101.88	38.61	68.41	18.72	97.90
	2	106.93	104.88	40.19	70.08	20.23	100.39
11	1	91.57	87.53	28.14	39.79	12.91	76.23
	2	92.78	93.39	30.79	42.51	15.13	80.18
12	1	99.31	96.41	31.22	41.90	16.29	106.62
	2	101.80	100.55	34.05	44.53	18.76	109.45
13	1	115.17	111.64	33.42	40.69	22.42	141.32
	2	116.33	117.45	36.46	42.93	24.45	144.86
14	1	92.46	90.06	29.15	40.65	12.89	73.77
	2	94.91	94.48	31.92	43.28	15.33	76.93

CHAPTER V

INTERPRETATION OF RESULTS

This chapter is concerned with the description of results obtained by applying the model to the data. Two optimal solutions were obtained in this study. Both the solutions used the same model and same data except that for solution one 1974-75 prices were used, whereas for the second solution 1971 prices were used. The objective of finding the second solution using 1971 prices was to see the workability of the model at other price levels. For this reason, only selected results of the second solution are compared with the results of solution one. The results of solution one are presented and compared in detail with the actual and/or normal situation of 1976 wherever possible. One should use caution in interpreting results in this chapter. The solution provides the optimal production plan for Manitoba crop production for the currently economical efficient farm firms.

The results were presented for the five agricultural regions and for Manitoba in this discussion. However, anyone interested in the optimal crop acreage results for each crop district, is referred to Table 47 and Table 49 of Appendix C. The crop districts were allocated to the five regions by taking the information from the Framingham et al[108] study, which is given in Table 46. In the following sections optimal crop acreage, optimal production levels of various crops, the employment of labor,

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[108] Framingham, Craddock and Baker _op_. _cit_.

TABLE 46

RELATIONSHIP OF CROP REPORTING DISTRICTS AND M.D.A. ADMINISTRATIVE REGIONS[1]

M.D.A. Administrative Regions	Crop Reporting Districts
Interlake	(4) + (12) + (6.4% of 5)
Eastern	(6) + (93.6% of 5)
Central	(3) + (70% of 2) + (48% of 8) + (33% of (9) + (24.6% of 14)
South West	(1) + (30% of 2) + (52% of 8) + (58% of 9) + (77% of 10) + (7)
North West	(11) + (23% of 10) + (75.4% of 14) + (9% of 9) + 13

[1]See Framingham, Craddock and Baker op. cit.

value of optimal crop production and net income in various regions are discussed.

Optimal Crop Acreage

The optimal crop acreage allocated to each crop in each crop district was arrived at by dividing the optimal total production of each crop by the appropriate yield. The resulting acreage figures were then summed to find the results for different regions and for Manitoba. The optimal acreage figures of solution one and actual 1976 acreage for the province as a whole are presented in Table 47. Total optimal acreage in solution one allocated to crops was higher by 20.57 percent than the actual acreage in 1976. The increase in cropped acreage came through a decrease in summerfallow area. This substitution of cropped area for the summerfallow area is consistent with the trend in land use in Manitoba: In the present study summerfallow area contributed about 17 percent to the total area available for crops, where as it constituted about 30 percent of the total cultivated area (i.e. cropped area and summerfallow) in 1961 which dropped to 23 percent in 1971.[109] Similar trend about the decrease in summerfallow acreage is reported in other studies.[110]

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[109] Calculated from Dominion Bureau of Statistics, Census of Canada, Agriculture, Manitoba, op. cit. 1963 and Statistics Canada, Census of Canada, Agriculture, Manitoba, op. cit. 1973.

[110] Hedlin R.A.,"The Place of Summerfallow in Manitoba Agriculture" paper presented at Soils and Fertilizer Conference , Winnipeg and Brandon, February 20 and 21, 1975.

TABLE 47

ACTUAL AND OPTIMAL ACREAGE IN SOLUTION ONE
ALLOCATED TO VARIOUS CROPS AND PERCENT INCREASE
IN OPTIMAL ACREAGE OVER ACTUAL ACREAGE IN MANITOBA

Crop	Optimal Acreage Under Solution 1	Actual[1] Acreage	Percent Change in Optimal Acreage Over Actual Acreage
	----Acres------	-----Acres-----	-----Percent-------
Wheat	3,297,346	3,798,098	-13.18
Oats	1,611,676	1,218,209	+32.80
Barley	2,147,705	1,638,042	+31.11
Flaxseed	1,143,730	521,212	+119.44
Rapeseed	654,561	224,056	+192.14
Rye	134,034	90,969	+47.34
Sunflower	129,607	49,591	+161.35
Potatoes	27,632	34,504	-19.92
Sugarbeets	26,490	32,936	-19.57
Total	9,172,781	7,607,617	+20.57

[1]Statistics Canada, Census of Agriculture, Ottawa, 1976.

Optimal acreage allocated to wheat, potatoes and sugarbeets was lower by 13.18 percent, 19.92 percent and 19.57 percent respectively than the actual acreage in Manitoba. Low acreage of these crops as compared with the actual acreage might be due to the realization of relatively higher net income from these crops over the previous years because of higher prices and the expectations of the farmers that net income from these crops would remain high for 1976.

The optimal acreage allocated to other crops was substantially higher than the actual acreage in 1976. For example, optimal acreage in solution one occupied by rapeseed, sunflower and flaxseed was higher by 192.14 percent, 161.35 percent and 119.44 percent, respectively, than the actual acreage. Similarly for oats, barley and rye, optimal acreage was higher by 32.8 percent, 31.11 percent and 47.34 percent, respectively, than the actual acreage in Manitoba. From this one can conclude that an efficient organization of agriculture practised on optimum sized farms not only would lead to an increase in the total cropped area but also would substantially change the pattern of land use in Manitoba. Crops like rapeseed and flaxseed would become more important, while the share of wheat would decline in the total cropped area.

Comparison of solution two with solution one optimal acreage indicated that the total cropped area in solution two was lower by 32.65 percent than in solution one for the province. The percent decrease in the cropped area of each crop in solution two over solution one is shown in Table 48. All the crops with the exception of sunflower and potatoes experienced a decrease in cropped area in solution two as compared with solution one. This was the result of lower and negative net income per acre due to low prices associated with almost all the crops

TABLE 48

PERCENT DECREASE IN AREA IN SOLUTION TWO OVER SOLUTION ONE FOR DIFFERENT CROPS[1]

Crop	Percent Decrease
Wheat	6.39
Oats	52.92
Barley	33.75
Flaxseed	73.24
Rapeseed	43.58
Rye	60.74
Sunflower	--
Potatoes	--
Sugarbeet	8.49
Total	32.65

[1]Calculated from the results of solution one and solution two obtained through the application of the model.

in various crop districts in solution two as shown in Table 44 of the Appendix C compared to solution one, where the net income per acre was positive for all the crops. There was no decrease in cropped area for sunflowers and potatoes in solution two over solution one due to the fact that net income per acre from these crops was positive under both solutions in almost all crop districts, where the crops were grown. The optimal acreages allocated to various crops in solution two is given in Table 45 of the Appendix C.

Crop Production

Actual and normal production in 1976 and optimal production in solution one of different crops for the province is presented in Table 49. The total quantity of each crop produced was higher in the optimal solution one as compared to the actual production in 1976 with the exception of wheat and sugarbeets. Optimal level of wheat and sugarbeets production was lower by 4.1 percent and 3.38 percent respectively than the actual production. This was due to less acres allocated to these crops in the optimal solution as compared to the actual acreage. Low optimal acreage as compared with the actual acreage might be due to higher prices from these crops over previous years which resulted in higher net income and the expectation of the farmers that prices and net income per acre of these commodities remain high for 1976. The production of other crops was higher from 16.7 to 267.3 percent in our solution as compared to the actual production levels as shown in Table 50. This was caused by either one of two factors or both:

1. higher levels of acres occupied by crops under the optimal

TABLE 49

OPTIMUM SOLUTION ONE, ACTUAL AND NORMAL PRODUCTION OF VARIOUS CROPS IN MANITOBA IN 1976

Crop	Optimum[a] Production	Actual[b] Production	Normal[c] Production
	----------	bushels	----------
Wheat	98,726,972	101,615,200	65,551,720
Oats	94,752,449	57,052,560	50,857,000
Barley	102,514,424	64,159,600	83,245,740
Flaxseed	16,029,994	6,177,548	7,312,097
Rapeseed	14,815,667	4,033,006	9,787,491
Rye	3,806,158	2,583,516	2,622,411
Sunflowers	141,029,962[d]	52,566,410[d]	90,897,880[d]
Potatoes	8,165,996	6,993,952	7,758,400
Sugarbeets	396,211[e]	410,053[e]	329,682[e]

[a]Based on the model

[b]Total production of each crop was obtained by multiplying the yield per acre with the area of each respective crop. For this purpose, area of various crops in different crop districts was obtained from Statistics Canada, Census of Canada, Agriculture, 1976. Yield per acre of wheat, oats, barley and flax was taken from Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Queen's Printer, Winnipeg, 1976. Due to the unavailability of yield per acre of other crops at crop district level, it was assumed that their yield per acre were the same in all crop districts. Their yields were also taken from Manitoba Department of Agriculture Yearbook, Queen's Printer, Winnipeg, 1976.

[c]Projected production for 1976 using time as independent variable.

[d]pounds

[e]tons

TABLE 50

PERCENT INCREASE OR DECREASE IN OPTIMAL SOLUTION ONE PRODUCTION AS COMPARED WITH ACTUAL AND NORMAL PRODUCTION[1]

Crop	Percent Increase or Decrease in Optimal Solution One Production Over	
	Actual Production	Normal Production
	Percent	
Wheat	-2.8	+50.6
Oats	66.0	+86.3
Barley	59.7	+23.1
Flaxseed	159.4	+119.2
Rapeseed	267.3	+51.4
Rye	47.3	+45.1
Sunflower	168.2	+55.2
Potatoes	16.7	+5.3
Sugarbeets	-3.3	+20.2

[1]Calculated from Table 49.

solution one, as compared to the actual acreage because of higher net income associated with these crops and due to the substitution of the area by these crops for wheat, potatoes and sugarbeets, and

2. higher yield per acre of different crops in our model as compared to the actual yield.

Since the actual production is greatly influenced by weather and other conditions, a comparison was made of optimal production levels of solution one with the normal production levels. Optimal production was higher than normal production by 5.3 percent to 119.2 percent for different crops. Higher production levels of various crops were caused by:

1. higher net income per acre from various crops due to higher prices of different commodities and higher yields per acre which were obtained at the recommended level practices, and

2. due to optimal organization which emphasized the concentration of crops in different regions according to their comparative advantage.

The increase in production which resulted from higher prices and due to the optimal organization of crop production could not be separated because of the nature of the model. Since the percentage increase in optimal production over the normal production for various crops was different, so it can be concluded that an efficient organization of agriculture would have a disproportionate effect on the production of various crops.

Optimal level of production of various crops in solution two was lower than the solution one by more or less the same percentage as the optimal acreages were lower, i.e. optimal level of wheat was lower by 5.80 percent, oats 52.46 percent, barley 30.55 percent, flaxseed

73.22 percent, rapeseed 42.26 percent, rye 60.51 percent and sugarbeets 8.13 percent. Optimal production levels of sunflowers and potatoes were the same under both solutions. Decreased production of most of the crops was caused by the low and negative net income per acre from most of the crops due to lower prices in solution two as compared with solution one which in turn resulted in low acreage allocation. Sunflowers and potatoes experienced the same level of production in solution one and solution two because there was no change in area occupied by these crops due to positive net income per acre from these crops under both solutions. Absolute level of production of various crops in solution two is given in Table 46 of the Appendix C.

Distribution of Optimal Acreage Among Regions

The optimal acreage figures of solution one for each agricultural region are presented in Table 51, while the results for each crop district are shown in Table 47 of the Appendix C. The actual acreage in 1976 allocated to different crops in various regions is shown in Table 52, while the percentage increase or decrease in acreage in the optimal solution one over the actual acreage is shown in Table 53. Central and South-West regions were the most important in terms of the increase in crop acreage. In these two regions crop acreage increased by 65.52 percent and 53.78 percent, respectively, over the actual acreage in 1976. This was the result of higher net income per acre of most crops in these regions. In both the Eastern and North-West regions, optimal crop acreage decreased by about 23 percent as compared to the actual acreage. This was because of low net income per acre for most of the crops in those regions due to lower yield per acre. There was almost no change in

TABLE 51

OPTIMAL ACREAGE ALLOCATED TO DIFFERENT CROPS IN VARIOUS REGIONS OF MANITOBA IN SOLUTION ONE [1]

Crop	Interlake	Eastern	Central	South West	North West	Manitoba
			Acres			
Wheat	177,264	318,163	1,059,838	1,151,815	590,270	3,297,346
Oats	145,166	206,939	504,654	499,335	255,585	1,611,676
Barley	183,678	205,609	672,312	677,826	408,284	2,147,705
Flaxseed	57,050	90,026	514,702	357,981	123,972	1,143,730
Rapeseed	32,473	108,835	194,207	211,013	108,033	654,561
Rye	7,314	5,392	46,460	51,192	23,676	134,034
Sunflower	5,941	1,176	53,169	65,720	3,602	129,607
Potatoes	1,737	0	11,797	13,040	1,059	27,632
Sugarbeets	2,998	0	16,594	6,403	495	26,490
Total	613,620	936,140	3,073,730	3,034,321	1,514,974	9,172,781

[1] Based on the model.

TABLE 52

ACTUAL ACREAGE ALLOCATED TO DIFFERENT CROPS IN VARIOUS REGIONS OF MANITOBA[1]

Crop	Interlake	Eastern	Central	South West	North West	Manitoba
			Acres			
Wheat	306,916	613,088	981,966	923,707	972,421	3,798,098
Oats	102,048	172,300	292,333	309,830	341,697	1,218,209
Barley	111,333	222,461	368,970	442,652	492,652	1,638,042
Flaxseed	57,134	118,837	107,775	168,902	68,563	521,212
Rapeseed	15,495	53,688	34,038	56,423	64,412	224,056
Rye	5,075	29,547	17,301	24,555	14,491	90,969
Sunflower	2,436	3,729	19,110	22,978	1,338	49,591
Potatoes	2,204	--	14,939	16,135	1,225	34,504
Sugarbeets	3,802	--	20,586	7,969	578	32,936
Total	606,443	1,213,648	1,857,016	1,973,149	1,957,349	7,607,617

[1]Calculated from Statistics Canada, Census of Agriculture, Ottawa, 1976.

TABLE 53

PERCENT INCREASE OR DECREASE OF THE OPTIMAL ACREAGE OF SOLUTION ONE OVER THE ACTUAL ACREAGE ALLOCATED TO DIFFERENT CROPS IN VARIOUS REGIONS AND IN MANITOBA[1]

Crop	Interlake	Eastern	Central	South West	North West	Manitoba
Wheat	-42.24	-48.10	+7.93	+24.69	-39.30	-13.18
Oats	+42.25	+20.10	+72.63	+61.16	-25.20	+32.30
Barley	+64.98	-7.57	+82.21	+53.13	-17.12	+31.11
Flaxseed	-0.15	-24.24	+377.57	+111.95	+80.81	+119.44
Rapeseed	+109.57	+102.72	+470.56	+273.98	+67.72	+192.14
Rye	+44.12	-81.75	+168.54	+108.48	+63.38	+47.34
Sunflowers	+143.88	-68.46	+178.23	+186.01	+169.21	+161.35
Potatoes	-13.02	--	-26.63	-19.18	-15.68	-19.92
Sugarbeets	-26.82	--	-19.39	-19.65	-14.36	-19.57
Total	+1.18	-22.86	+65.52	+53.78	-22.60	20.57

[1]Calculated from Table 51 and 52.

solution one acreage and the actual crop acreage in 1976 in Interlake area. This brings us to the conclusion that certain interregional adjustments would be needed if the agricultural industry is to be organized efficiently. The Eastern and North-West regions would become less important in terms of their share to total cropped area, while the contribution of the Central and South-West regions would increase. Thus the competitive position of Eastern and North-West regions declines as compared to the Central and South-West regions with an efficient organization of crop production. This was caused by higher yields of most of the crops in the Central and South-West regions as compared to the Eastern and North-West regions. Thus the proper utilization of land in Manitoba would require that the East and NorthWest regions should persumable engage increasingly in pastoral farming, while the Central and Southwest regions should concentrate moe in crop production at the expense of summerfallow average.

The percentage decrease of total optimal acreage in solution two over solution one indicated that the South-West and Central regions experienced the least decrease in optimal acreage as compared to other regions, i.e. total optimal acreage decreased by 19.19 percent and 28.86 percent respectively, in solution two over solution one as shown in Table 48, Appendix C. This was the result of less loss or higher net income per acre associated with most of these crops in each region. In the North-West, Interlake and Eastern regions total optimal acreage was lower by 37.32 percent, 52.06 percent and 68.48 percent, respectively, in solution two over solution one. This was due to lower net income per acre for most crops in these regions. The optimal acreage allocated to the various crops in different crop districts in solution two is given in Table 49 of the Appendix C.

The percentage increase or decrease in the optimal acreage in solution one for each crop as compared to the actual acreage showed a wide deviation of the optimal acreage from the actual acreage in different regions. For example, rapeseed occupied a 470.56 percent higher area in the Central region as compared with the actual one, while the wheat crop occupied 48.10 percent less area in the optimal solution as compared with the actual area in the Eastern-region. These two figures show the range by which the optimal acreage of different crops was higher or lower than the actual acreage. The increase in the optimal acreage of wheat in the Central and South-West regions over the actual acreage was the result of higher yield and consequently higher net income per acre in these regions. Similarly, the increased concentration of rapeseed acreage in the optimal solution in the Central region was the result of higher yield and resulting higher net income per acre from this crop in this region as compared to other regions. Again, consider the oat crop. Oat acreage decreased compared to actual acreage in the North-West region because of low yield in the region as compared to other regions. The Central and South-West regions experienced an increase of 72.63 percent and 61.61 percent due to the fact that these regions ranked first and second in terms of yield per acre.

The percentage distribution of total optimal acreage in solution one, for each crop among regions, is shown in Table 54.

The Central and South-West regions were the most important in terms of their contribution to total optimal acreage. Individually both regions contributed about one-third of the total optimal crop acreage. The North-West region was next in importance followed by the Eastern region. The Interlake region contributed only 6.7 percent of the total

TABLE 54

THE PERCENTAGE DISTRIBUTION OF OPTIMAL CROP ACREAGE AMONG VARIOUS REGIONS IN SOLUTION ONE[1]

Crop	Interlake	Eastern	Central	South West	North West	Province
	Percent					
Wheat	5.38	9.65	32.14	34.93	17.90	100.00
Oats	9.01	12.84	31.31	30.98	15.86	100.00
Barley	8.55	9.57	31.30	31.56	19.02	100.00
Flaxseed	4.99	7.87	45.00	31.30	10.84	100.00
Rapeseed	4.96	16.63	29.67	32.24	16.50	100.00
Rye	5.46	4.02	34.66	38.20	17.66	100.00
Sunflower	4.58	0.91	41.02	50.71	2.78	100.00
Potatoes	6.29	0.00	42.69	47.19	3.83	100.00
Sugarbeets	11.32	0.00	62.64	24.17	1.87	100.00
	6.69	10.20	33.51	33.08	16.52	100.00

[1]Calculated from Table 51.

optimal acreage. In comparison with the actual percentage distribution of total cropped acreage among regions given in Table 55, the Central and South-West regions shared substantially more, while the other regions shared proportionately less of the total optimal acreage compared with actual acreage. The reasons for these results are as already explained in the previous discussion. This indicates the potential for development of the Central and South-West region as compared with the other regions.

With regard to the percentage contribution of each region towards the optimum acreage as compared with the actual one, it varied from crop to crop. An important observation which can be made was that the Central and South-West regions were the most important for almost all the crops in solution one as compared with the actual situation. This was the result of higher yields and net income for most of the crops in those two regions. Thus the competitive position of the Central and South-West regions would increase with an efficient organization of crop production.

Comparison of the percent distribution of total optimal acreage in the two solutions indicated that the percent contributions of the South-West and Central regions were higher in solution two as shown in Table 50 of the Appendix C as compared to solution one, while the percentage share of the other regions were lower in solution two than in solution one. This was due to the fact that South-West and Central regions had less loss or higher net income from most of the crops as compared to the other regions.

TABLE 55

THE ACTUAL PERCENTAGE DISTRIBUTION OF CROP ACREAGE AMONG VARIOUS REGIONS OF MANITOBA [1]

Crop	Interlake	Eastern	Central	South West	North West	Province
	Percent					
Wheat	8.08	16.14	25.85	24.32	25.61	100.00
Oats	8.38	14.14	24.00	25.43	28.05	100.00
Barley	6.80	13.58	22.53	27.02	30.07	100.00
Flaxseed	10.96	22.80	20.68	32.41	13.15	100.00
Rapeseed	6.92	23.96	15.19	25.18	28.75	100.00
Rye	5.58	32.48	19.02	26.99	15.93	100.00
Sunflower	4.91	7.52	38.54	46.33	2.70	100.00
Potatoes	6.39	0.0	43.30	46.76	3.55	100.00
Sugarbeets	11.54	0.0	62.50	24.20	1.76	100.00
	7.97	15.95	24.41	25.94	25.73	100.00

[1] Calculated from Table 52.

Competitiveness Between Crops

The percentage of the optimal and actual total cropped area occupied by different crops in various regions and in Manitoba is given in Table 56 and Table 57. Important changes in the cropping pattern for the province as a whole under the optimal solution as compared with the actual one include a decrease in the percentage area occupied by wheat and an increase in the relative area allocated to flaxseed and rapeseed. This leads to the conclusion that with an efficient organization of agriculture the relative importance of wheat would decrease while flaxseed and rapeseed would become more important in terms of their contribution to total cropped area. Thus the competitive acreage of wheat would decline, while that of flaxseed and rapeseed would increase with an efficient organization of crop production. This might be due to the fact that differences in crop prices were more in the model than the actual differences in prices in 1975.

Distribution of Production Among Regions

The distribution of optimal production in solution one for different crops in various regions is depicted in Table 58. The Central and South-West regions were the most important in terms of contribution towards total production of all crops. The share of these regions ranged from 60.03 percent for rapeseed to 91.48 percent for sunflower relative to total production in Manitoba. This can be explained by two factors:

1. these two regions collectively contributed 66.59 percent of the total land used for all cultivated crops in Manitoba, and

TABLE 56

THE PERCENTAGE OF VARIOUS CROP ACREAGE IN SOLUTION ONE BY REGIONS AND IN MANITOBA[1]

Crop	Interlake	Eastern	Central	South West	North West	Province
	Percent					
Wheat	28.89	33.99	34.48	37.96	38.96	35.95
Oats	23.66	22.11	16.42	16.46	16.87	17.57
Barley	29.93	21.96	21.87	22.34	26.95	23.41
Flaxseed	9.30	9.62	16.75	11.80	8.18	12.47
Rapeseed	5.27	11.63	6.32	6.95	7.13	7.14
Rye	1.19	0.58	1.51	1.69	1.56	1.46
Sunflower	0.97	0.13	1.73	2.17	0.24	1.41
Potatoes	0.28	0.00	0.38	0.43	0.07	0.30
Sugarbeets	0.49	0.00	0.58	0.21	0.03	0.29
Total	100.00	100.00	100.00	100.00	100.00	100.00

[1]Calculated from Table 51.

TABLE 57

THE PERCENTAGE OF VARIOUS CROP ACREAGE IN THE TOTAL ACTUAL ACREAGE BY REGIONS AND IN MANITOBA [1]

Crop	Interlake	Eastern	Central	South West	North West	Province
			Percent			
Wheat	50.61	50.52	52.88	46.81	49.68	49.92
Oats	16.83	14.20	15.74	15.70	17.46	16.01
Barley	18.36	18.33	19.87	22.43	25.17	21.53
Flaxseed	9.42	9.79	5.80	8.56	3.50	6.85
Rapeseed	2.56	4.42	1.83	2.86	3.29	2.95
Rye	0.84	2.43	0.93	1.24	0.74	1.20
Sunflower	0.40	0.31	1.03	1.16	0.07	0.65
Potatoes	0.36	0.00	0.80	0.82	0.06	0.45
Sugarbeets	0.63	0.00	1.11	0.40	0.03	0.43
Total	100.00	100.00	100.00	100.00	100.00	100.00

[1] Calculated from Statistics Canada, Census of Agriculture, Ottawa, 1976.

TABLE 58

DISTRIBUTION OF OPTIMAL PRODUCTION AMONG REGIONS[1]

Crop	Interlake		Eastern		Central		South West		North West		Total
	Quantity Produced (In Bu.)	Percent of Total	Quantity Produced (In Bu.)	Percent of Total	Quantity Produced (In Bu.)	Percent of Total	Quantity Produced (In Bu.)	Percent of Total	Quantity Produced (In Bu.)	Percent of Total	(In Bushels)
Wheat	5,375,886	5.45	8,680,111	8.79	32,307,364	32.72	34,865,265	35.32	17,498,344	17.72	98,726,972
Oats	8,008,004	8.45	11,447,462	12.08	31,457,740	32.20	29,944,715	31.60	13,894,526	14.67	94,752,449
Barley	8,138,678	7.94	8,611,319	8.40	33,691,907	32.87	34,436,075	33.59	17,636,443	17.20	102,514,424
Flaxseed	890,644	5.56	1,254,055	7.82	6,929,616	43.23	5,220,548	32.57	1,734,831	10.82	16,029,994
Rapeseed	747,320	5.04	2,297,959	15.51	4,491,154	30.31	4,846,736	32.72	2,432,499	16.42	14,815,667
Rye	210,502	5.53	139,380	3.66	1,334,269	35.06	1,458,374	38.31	663,635	17.44	3,806,158
Sunflowers	6,766,975*	4.80	1,155,023*	0.82	58,584,124*	41.54	70,436,837*	49.94	4,086,998*	2.90	141,029,962*
Potatoes	522,000	6.39	0	0.0	3,535,359	43.29	3,818,428	46.76	290,210	3.56	8,165,996
Sugarbeets	45,722**	11.54	0	0.0	247,660**	62.51	95,874**	24.20	6,956**	1.75	396,211**

[1]Based on the model

* in pounds

** in tons

2. the higher level of yield per acre of most crops in the two regions as compared to other regions. The north-West region contributed 1.75 to 17.72 percent for different crops to the total production of the province. The contributions of Interlake and Eastern regions were much lower as compared to the Central and South-West regions. This was due to lower yield per acre of most crops and less acres allocated to various crops. In order to make the distributional comparison with the optimal production of solution one and normal and actual production among regions is given in Table 59 while that of actual production is shown in Table 60. For ease of comparison, percentages are also given in these Tables in order to compare with the percentage optimal production data shown in Table 58. Production was mostly apportioned among regions in the same manner under the optimal and normal production conditions. Some of the important deviations between the optimal and normal productions are:

1. Production of flaxseed was heavily concentrated in the central region in the optimal solution as compared with the normal production, while the results were opposite for the South-West region.

2. Percentage share of rapeseed production of the Eastern region in the optimal solution was higher than in the normal production case. There was a lessor share of this crop in the Central region in the optimal solution as compared with normal production.

3. For rye, the South-West and North-West regions contributed more to total production in the optimal solution than in normal production, while the Eastern region shared considerable less in solution one than under normal conditions.

TABLE 59

DISTRIBUTION OF NORMAL PRODUCTION AMONG REGIONS

Crop	Interlate Quantity Produced (In Bu.)	Interlate Percent of Total	Eastern Quantity Produced (In Bu.)	Eastern Percent of Total	Central Quantity Produced (In Bu.)	Central Percent of Total	South West Quantity Produced (In Bu.)	South West Percent of Total	North West Quantity Produced (In Bu.)	North West Percent of Total	Total (In Bushels)
Wheat	3,808,873	5.81	7,485,356	11.42	22,340,880	34.08	21,846,460	33.33	10,070,580	15.36	65,551,720
Oats	4,972,403	9.78	6,400,805	12.59	15,741,500	30.94	16,048,520	31.56	7,693,850	15.13	50,857,000
Barley	6,138,535	7.37	6,413,195	7.70	28,325,550	34.03	28,848,890	34.66	13,519,550	16.24	83,245,740
Flaxseed	538,771	7.36	371,800	5.08	2,462,851	33.68	3,122,835	42.72	815,835	11.16	7,312,097
Rapeseed	568,640	5.81	1,117,633	11.42	3,335,702	34.09	3,261,879	33.32	1,503,631	15.36	9,787,491
Rye	152,358	5.81	299,454	11.42	893,752	34.09	873,972	33.32	402,875	15.36	2,622,411
Sunflower	4,465,027*	4.91	6,835,123*	7.52	35,027,710*	38.54	42,117,530*	46.33	2,452,490*	2.70	90,897,880*
Potatoes	495,581**	6.39	--	--	3,359,180**	43.30	3,628,100**	46.76	275,535**	3.55	7,758,400**
Sugarbeets	38,057	11.54	--	--	206,066	62.50	79,769	24.20	5,790	1.76	329,682

[1] Projected production for 1976 using time as independent variable.

* in pounds

** in tons

TABLE 60

DISTRIBUTION OF ACTUAL PRODUCTION AMONG REGIONS[1]

Crop	Interlake		Eastern		Central		South West		North West		Total (In Bu.)
	Quantity Produced (In Bu.)	Percent of Total	Quantity Produced In Bu.	Percent of Total	Quantity Produced (In Bu.)	Percent of Total	Quantity Produced (In Bu.)	Percent of Total	Quantity Produced (In Bu.)	Percent of Total	
Wheat	8,279,816	8.14	17,280,860	17.01	26,785,790	26.36	3,361,230	22.99	25,907,500	25.50	101,615,200
Oats	4,454,879	7.81	8,558,539	15.00	14,420,800	25.28	5,501,890	27.17	14,116,470	24.74	57,052,560
Barley	4,354,816	6.79	9,187,881	14.32	15,374,780	23.96	8,286,190	28.50	16,955,930	26.43	64,159,600
Flaxseed	667,162	10.80	1,497,866	24.25	1,207,383	19.54	1,994,489	32.29	810,649	13.12	6,177,548
Rapeseed	278,913	6.92	966,381	23.96	612,676	15.19	1,015,616	25.18	1,159,421	28.75	4,033,006
Rye	144,138	5.58	839,126	32.48	491,361	19.02	697,354	26.99	411,539	15.93	2,583,516
Sunflowers	2,582,134*	4.91	3,952,765*	7.52	20,256,600*	38.54	24,356,640*	46.33	1,418,280*	2.70	52,566,410*
Potatoes	446,751	6.39	--	--	3,028,196	43.30	3,270,620	46.76	248,386	3.55	6,993,952
Sugarbeets	47,335**	11.54	--	--	256,301**	62.50	99,216**	24.20	7,201**	1.76	410,053**

[1] See Footnote b under Table 49 for the procedure used for determining production.

* pounds

** tons

4. The Eastern region shared less and Central and South-West regions contributed more to sunflowers in solution one as compared with normal production.

Comparison of the optimal production of solution one and actual production indicated that the production of all crops with the exception of sunflowers, potatoes and sugarbeets was heavily concentrated in the Central and South-West regions in the optimal solution as compared with the actual production distribution. For example, Central and South-West regions collectively shared 68.04 percent of the total production of wheat under the optimal solution as compared to the 47.35 percent under the actual production. Similarly, Central and South-West regions contributed 75.8 percent of the total flaxseed production in the optimal solution as compared to 51.83 percent under the actual production. Percentage share in the production of sunflowers, potatoes and sugarbeets was the same under the optimal solution one and the actual production in various regions. In the production of almost all other crops, Interlake, Eastern and North-West regions experienced a much lower share of the optimal solution as compared to the actual production.

The percentage increase or decrease in the optimal production in solution one over the normal production for each crop in each region was also calculated and is given in Table 61. It is clear from the table that with the exception of sunflowers and rye production in the Eastern region, optimal production of all crops in all regions was higher than the normal production. Low production of rye and sunflowers in the Eastern region occurred because of low net income per acre associated with low yields in this region as compared to other regions. This caused a comparative disadvantage in the production of these crops in the region as is discussed in the next section. Flaxseed was the crop whose production

TABLE 61

PERCENT INCREASE OR DECREASE OF OPTIMAL SOLUTION ONE PRODUCTION OVER THE NORMAL PRODUCTION IN VARIOUS REGIONS AND IN MANITOBA[1]

Crop	Interlake	Eastern	Central	South West	North West	Manitoba
Wheat	+41.14	+15.96	+44.61	+59.59	+73.76	+50.61
Oats	+61.05	+78.84	+99.84	+86.59	+80.59	+86.31
Barley	+32.58	+34.28	+18.95	+19.37	+30.45	+23.15
Flaxseed	+65.31	+237.29	+181.37	+67.17	+112.64	+119.23
Rapeseed	+31.42	+105.61	+34.64	+48.59	+61.77	+51.37
Rye	+38.16	-53.45	+49.29	+66.87	+64.72	+45.14
Sunflower	+51.56	-83.10	+67.25	+67.24	+66.65	+55.15
Potatoes	+5.33	--	+5.24	+5.25	+5.33	+5.25
Sugarbeets	+20.14	--	+20.18	+20.18	+20.14	+20.18

[1]Calculated from Table 58 and 59.

showed the greatest increase over normal production. This was followed by oats. Potatoes realized the least percentage increase in production in solution one in various regions. Higher levels of production of each crop in each region can be explained in the same way as the higher level of optimal production over the actual production for the province.

It can be observed from Table 62 that all the crops with the exception of wheat and sugarbeets observed an increase in production in solution one over the actual production in the Central and South-West regions. This was caused by either higher yield or more acreage or both the factors in these regions. Interlake, South-West and North-West regions experienced an increase in production of some of the crops and a decrease in other crops in the optimal solution as compared to the actual production. Lower levels of production of crops in these regions were the result of less number of acres allocated to these crops in optimal solution one as compared to the actual acreage. Flaxseed observed the highest increase in production in optimal solution one (i.e. 119.23 percent) over the normal production. However, rapeseed ranked first in experiencing an increase (i.e. 267.36 percent) in production in optimal solution one over the actual production. Much higher levels of production of most of the crops specifically those of oilseeds in the optimal solution as compared to the actual production levels might be the result of:

1. relatively higher prices of oilseeds in the model as compared to the relative prices realized by farmers over previous years as compared to the prices of grains and,

2. higher yields of different crops due to the use of efficient methods of production in the optimal solution as compared to the actual conditions.

TABLE 62

PERCENT INCREASE OR DECREASE OF OPTIMAL SOLUTION ONE PRODUCTION OVER THE ACTUAL PRODUCTION IN VARIOUS REGIONS AND IN MANITOBA[1]

Crop	Interlake	Eastern	Central	South West	North West	Manitoba
Wheat	-35.07	-49.77	+20.61	+49.24	-32.45	-2.84
Oats	+79.76	+33.75	+118.14	+93.17	-1.57	+66.08
Barley	+86.89	-6.28	+119.13	+88.32	+4.01	+59.78
Flaxseed	+33.50	-16.28	+473.94	+161.75	+114.01	+159.49
Rapeseed	+167.94	+137.79	+633.04	+377.22	+109.80	+267.36
Rye	46.04	-83.39	+171.55	+109.13	+61.26	+47.32
Sunflowers	162.07	-70.78	+189.22	+189.19	+188.17	+168.29
Potatoes	16.84	--	+16.75	+16.75	+16.84	+16.76
Sugarbeets	-3.52	--	-3.37	-3.37	-3.40	-3.38

[1] Calculated from Table 58 and Table 60.

Comparative Advantage in Production of Various Crops in Different Regions

In order to see the comparative advantage in the production of various crops in different regions, a comparison of the percent contribution of regions towards the total production was made with the availability of land. That is, if a particular region contributes P percent towards the total production of a particular crop and if the land available to this region is greater than P percent, then this region has comparative disadvantage in the production of this crop. Conversely, if a particular region allocates less than P percent, then that region have a comparative advantage in the production of the crop.

Using this criterion, comparative advantage and disadvantage which different regions enjoyed was determined. Land area available figures given in Table 63 were compared with the percentage contribution of different regions towards total production from Table 58.

For the wheat and barley crop it was found that the Central and North-West regions have a comparative advantage and the Interlake region a comparative disadvantage. The Eastern and South-West regions have neither comparative advantage nor comparative disadvantage in their production.

The Eastern and Central regions have comparative advantage in the production of oats, while a comparative disadvantage was experienced in the Interlake and South-West regions.

The Central region has a comparative advantage in the production flaxseed, while the Interlake, South-West and North-West have a

TABLE 63

LAND AVAILABLE TO DIFFERENT REGIONS[1]

Region	Land Available	
	Acres	Percent of Manitoba
Interlake	1,268,545	11.50
Eastern	941,476	8.54
Central	3,267,835	29.62
South West	3,818,264	34.62
North West	1,733,942	15.72
Manitoba	11,030,062	100.00

[1]Calculated from Table 4.

comparative disadvantage.

Production of rapeseed has neither comparative advantage nor disadvantage in the Central, South-West and North-West regions, while it has a heavy comparative advantage in the in the Eastern region and a comparative disadvantage in the Interlake region.

Production of rye has a comparative disadvantage in the Interlake and Eastern regions and a comparative advantage in the Central, South-West and North-West regions.

A heavy comparative advantage is associated with the production of sunflowers and potatoes in the Central and South-West regions, and a comparative disadvantage in the Interlake, Eastern and North-West regions.

Production of sugarbeets has comparative advantage in the Central region and a comparative disadvantage in the Eastern, North-West and South-West regions, while the Interlake regions have neither comparative advantage nor disadvantage.

Distribution of Employment Among Regions

The geographical distribution of total employment in solution one is shown in Table 64. The amount of labor employed was calculated by dividing the number of hours required in different regions by the standard working hours per man year. Since a laborer is entitled to two weeks vacation[111] and the General Holidays[112] amount to two weeks,

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[111] See "The Vacation With Pay Act", S.M., 1966, c.70, S.1, Section 5(1).

[112] Susan Walters, Canadian Almanac and Directory, Copp. Clark Pub-Publishing, Toronto1977, p. 25.

TABLE 64

LABOR REQUIREMENT FOR DIFFERENT REGIONS AND FOR MANITOBA IN SOLUTION ONE[1]

Region	Labor Required (In Man Years)	Percent of Total
Interlake	674	7.52
Eastern	1,001	11.17
Central	3,143	35.06
South West	2,719	30.33
North West	1,427	15.92
Province	8,964[2]	100.00

[1]Based on the model.

[2]Excluded management.

TABLE 65

LABOR REQUIRED PER ACRE FOR DIFFERENT CROPS IN VARIOUS CROP DISTRICTS FOR SOIL TYPE ONE[1]

Crop District	Wheat	Oats	Barley	Flaxseed	Rapeseed	Rye	Sunflower	Potatoes	Sugarbeets
	-----	-----	-----	-----	hours	-----	-----	-----	
1	1.63	1.66	1.59	1.54	1.48	1.60	1.58	--	--
2	1.65	1.67	1.60	1.52	1.47	1.60	1.58	14.35	20.72
3	2.03	2.09	2.00	2.01	1.97	2.00	1.58	14.35	20.72
4	2.10	2.07	2.00	1.97	1.97	2.00	1.58	14.35	20.72
5	2.04	2.04	2.00	2.00	1.96	2.00	1.58	--	--
6	2.40	2.30	2.32	2.12	2.18	2.31	--	--	--
7	1.65	1.67	1.61	1.53	1.49	1.63	1.58	14.35	--
8	1.65	1.68	1.60	1.56	1.49	1.59	1.58	14.35	--
9	1.65	1.67	1.60	1.56	1.49	1.61	--	14.35	20.72
10	1.68	1.74	1.65	1.58	1.52	1.64	--	14.35	20.72
11	1.78	1.85	1.79	1.73	1.73	1.75	1.58	14.35	20.72
12	2.40	2.30	2.34	2.11	2.16	2.31	--	14.35	--
13	1.79	1.87	1.80	1.75	1.72	1.77	--	--	--
14	2.42	2.28	2.25	2.28	2.14	2.36	--	--	--

TABLE 66

LABOR REQUIRED PER ACRE FOR DIFFERENT CROPS
IN VARIOUS CROP DISTRICTS FOR SOIL TYPE 2

Crop District	Wheat	Oats	Barley	Flaxseed	Rapeseed	Rye	Sunflower	Potatoes	Sugarbeets
				-hours-					
1	1.79	1.82	1.74	1.74	1.64	1.75	1.58		
2	1.81	1.84	1.76	1.72	1.64	1.76	1.58	14.35	20.72
3	2.03	2.09	2.00	2.01	1.97	2.00	1.58	14.35	20.72
4	2.10	2.07	2.00	1.97	1.97	2.00	1.58	14.35	20.72
5	2.04	2.04	2.00	2.00	1.96	2.00	1.58	--	--
6	1.96	1.94	1.93	1.85	1.77	1.90	--	--	--
7	1.81	1.84	1.77	1.73	1.65	1.79	1.58	14.35	--
8	1.81	1.85	1.77	1.76	1.65	1.75	1.58	14.35	--
9	1.82	1.83	1.76	1.77	1.65	1.76	--	14.35	20.72
10	1.84	1.91	1.82	1.78	1.69	1.80	--	14.35	20.72
11	1.79	1.77	1.69	1.67	1.52	1.68	1.58	14.35	20.72
12	1.95	1.95	1.95	1.85	1.76	1.91	--	14.35	--
13	1.81	1.77	1.74	1.71	1.50	1.72	--	--	--
14	1.96	1.93	1.89	1.92	1.74	1.93	--	--	--

there are 48 working weeks. These weeks were multiplied with the standard 40 hours of work per week.[113] Thus 1920 hours per year was used as one man year. In solution one, total employment of labor for crop production came to 8,964 laborers. Among regions, the Central region had total employment of 3,143 or 35.06 percent of the total employment in the crop sector. The South-West region was the next in importance with employment of 2,719 or 30.33 percent of total employment. The North-West region provided only half as much employment as South West region. The total labor requirement in the Eastern region came to 1,001 or 11.17 percent of total employment. The Inter-lake region was the least important in terms of labor provision with 674 laborers or 7.52 percent of the total. The various levels of employment by regions can be explained in terms of the total acreage allocated to different crops and the labor requirement per cropped acre. The Central region with the highest employment also contributed the most towards the total cropped area in Manitoba. Contrary to this, the percentage contribution of the Interlake area to the Manitoba crop acreage was lowest.

Actual labor requirement for crop production for 1976 came to 8,609 man years as shown in Table 67 which was lower by 3.96 percent than the labor estimated in solution one. This was due to the fact that the actual acreage allocated to crops was lower as compared to the optimal solution one acreage. If actual acreage allocated to crops had been as much as the optimal acreage, then the actual labor required for

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[113] "The Employment Standards Act" S.M.; 1957, c.20, s.1, Section 31(1).

TABLE 67

ACTUAL LABOR REQUIREMENT FOR DIFFERENT REGIONS AND FOR MANITOBA[1]
(In Man Years)

Region	Labor Required (In Man Years)	Percent of Total
Interlake	756	8.78
Eastern	1,335	15.51
Central	2,268	26.34
South West	2,170	25.21
North West	2,080	24.16
Province	8,609	100.00

[1]Actual labor requirement was estimated by projecting the farm area from census reports for 1976 that would lie in three farm sizes (i.e. under 240 acres, 240 to 759 acres, and over 759 acres). This was done because the labor needed per acre varied on various sized farms and due to the availability of labor data per acre for different crops for these three sizes. These three sizes constituted 3.61 percent, 37.95 percent and 58.44 percent of the farm area in 1976. Area of each crop on each size and soil type in various crop districts was determined by weighing according to the percent area lying in various sizes and according to the percent distribution of land in two soil types. Labor needed per acre according to the size and soil type was determined from Framingham, Craddock and Baker op. cit.

crop production for 1976 would have been higher by 15.80 percent. Distribution of optimal labor requirement was more concentrated in the Central and South-West regions as compared to the actual labor requirement distribution. This was the result of more concentration of cropped acreage under the optimal solution one as compared to the actual acreage.

In order to determine the total employment in the agriculture sector, labor requirements for livestock and poultry were estimated. For livestock and poultry, employment amounted to 23,335,564 hours or 12,154 man years as shown in Table 68. Thus the total employment of labor needed for the agriculture sector came to 21,118 laborers with an efficient organization of crop production. The total amount of employment projected for the agriculture sector in Manitoba was 42,000 for 1976.[114] Thus the total labor which would be released from agriculture sector amounted to 20,882. Out-migration of labor from the agriculture sector over time could be partly explained due to the redundancy of labor as the optimal and actual requirements were more or less the same.

Comparison of the total labor required for the two solutions indicated that total employment in solution two was lower by 35.82 percent as compared to solution one. Like the acreage, Central and South-West regions contributed more while the other regions shared less of the total employment in solution two as shown in Table 69, as compared to solution one.

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[114] One could object the validity of this projected figure, but it was used because of unavailability from some other source for comparison. It was taken from: Manitoba Department of Industry and Commerce, Manpower and Employment Outlook for Manitoba, 1975-77, September 15, 1977, p. 27.

TABLE 68

TOTAL LABOR REQUIRED FOR LIVESTOCK AND POULTRY

Kind of Livestock or Poultry	Labor Required Per Unit in Hrs.	Total Units in 1976[a]	Labor Required in Hrs.
Dairy Cow	60.000[b]	102,076[h]	6,124,560
Beef Cow	15.200[c]	440,924[h]	6,702,045
Heifer	5.956[c]	154,000	917,224
Calf	7.637[c]	387,000	2,955,519
Steer	8.538[d]	172,000	1,468,536
Hog	4.6[e]	247,500	2,277,000
Sheep	2.02[f]	19,000	38,380
Poultry	1.10	2,593,000	2,852,300
Total			23,335,564

[a]Source: Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Queen's Printer, Winnipeg, 1976.

[b]Manitoba Department of Agriculture, Farm Data Handbook, Economics Branch, 1972, III 22.

[c]The average amount of labor required for the low and high mechanization, See Ibid., IV 23.

[d]It was assumed that the labor requirement of Steer was the same as of long fed yearlings, See Ibid. IV 23.

[e]This figure is based on number of hogs produced and includes maintenance of breeding herd. Since it is possible to have two litters in one year, the number is multiplied by two to determine the total labor required for hog production. See: John R. Stephen, Swine Production in Ontario, Conventional Enterprises, Costs, Returns and Management, Farm Economics, Cooperatives and Statistics Branch, Ontario, Department of Agriculture and Food, 1966, p. 30.

[f]See V.M. Gleddie, Sheep Production Budgets 1970, Alberta Department of Agriculture, paper presented at the First Annual Sheep Symposium, Olds, Alberta, January 16-18, 1969.

[g]Manitoba Department of Agriculture, Farm Data Handbook, op. cit. VIII 28.

[h]Total number of bulls in Manitoba were divided into two categories on the basis of number of dairy cows and beef cows. These bull figures were included in the respective cow categories. It was assumed that the labor requirement for bulls were the same as for cows.

TABLE 69

LABOR REQUIREMENT FOR DIFFERENT REGIONS
AND FOR MANITOBA WITH SOLUTION TWO[1]

Region	Labor Required (In Man Years)	Percent of Total
Interlake	344	5.98
Eastern	319	5.54
Central	2,224	38.66
South West	2,226	38.69
North West	640	11.13
Province	5,753	100.00

[1]Based on the model.

Farm Crop Income and Distribution

Total gross crop farm income under the optimal solution one, actual and normal conditions with the same prices is given in Table 70. Value of optimal crop production totalled 1,170 million dollars, where as it came to 857 million dollars under actual production conditions and 768 million dollars under normal production.[115] In other words, total crop production value was higher by 36.52 percent and 52.31 percent as compared with the actual and normal conditions. Since the prices used for different crops in finding the value were the same under all conditions, the percentage by which the optimal production value of each crop would be higher or lower than the actual or normal production would be the same as those given in production Table 50. The value of optimal crop production in various regions and in Manitoba is shown in Table 71 and the percentage contribution of different regions towards the total value of production in Manitoba is depicted in Table 72. Comparison of these figures with the percentage figures for land used given in Table 73, indicates that the percentage contribution towards the total value of crops produced is slightly greater for Central and South-West regions and slightly lower for other regions as compared to the percentage share of land used in these regions.

The total value of crop production decreased by 77.74 percent under solution two as compared to solution one for the province. The total value of production was lower by 73.09 percent for wheat, 82.37 percent for oats, 77.17 percent for barley, 93.93 percent for flaxseed,

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[115]See Table 71.

TABLE 70

VALUE OF OPTIMAL SOLUTION ONE, ACTUAL AND NORMAL PRODUCTION OF VARIOUS CROPS IN MANITOBA[1]

Crop	Optimal Production Value	Actual Production Value	Normal Production Value
	Dollars		
Wheat	497,583,872	512,146,400	330,376,700
Oats	143,076,208	85,924,810	76,628,970
Barley	224,506,544	140,254,300	181,997,200
Flaxseed	146,995,040	56,627,370	67,025,680
Rapeseed	102,228,096	27,811,630	67,497,900
Rye	8,868,348	6,025,484	6,110,059
Sunflower	13,397,850	3,153,985	8,635,302
Potatoes	19,026,768	13,148,630	18,077,040
Sugarbeets	13,867,397	12,301,590	11,538,870
Total	1,169,550,210	857,392,800	767,886,500

[1]The same prices were used for calculating the actual and normal production values, as were used in determining the production values in solution one.

TABLE 71

VALUE OF OPTIMAL CROP PRODUCTION IN VARIOUS REGIONS AND IN MANITOBA IN SOLUTION ONE[1]

Crop	Interlake	Eastern	Central	South West	North West	Province
	----------	----------	----------	Dollars	----------	----------
Wheat	27,121,984	43,834,544	162,829,008	176,480,816	88,040,752	497,583,872
Oats	12,090,865	17,285,648	47,501,152	45,277,312	20,890,384	143,076,208
Barley	17,821,904	18,903,200	73,785,184	75,616,032	38,501,920	224,506,544
Flaxseed	8,169,134	11,499,681	63,544,544	48,106,928	15,889,143	146,995,040
Rapeseed	5,155,992	15,855,908	30,988,944	33,598,592	16,760,553	102,228,096
Rye	491,604	326,149	3,108,843	3,407,665	1,541,626	8,868,348
Sunflower	642,798	109,727	5,565,486	6,728,967	388,032	13,397,850
Potatoes	1,216,136	--	8,237,378	8,946,752	675,783	19,026,768
Sugarbeets	1,600,105	--	8,668,090	3,374,372	243,304	13,867,397
Total	74,310,532	107,814,892	404,228,679	401,537,497	182,931,528	1,169,550,210

[1]Based on the model.

TABLE 72

PERCENT CONTRIBUTION OF DIFFERENT REGIONS TOWARDS THE TOTAL VALUE OF PRODUCTION IN SOLUTION ONE[1]

Region	Percent Contribution
Interlake	6.35
Eastern	9.22
Central	34.56
South West	34.33
North West	15.64
Total	100.00

[1]Based on the model.

TABLE 73

LAND USED IN VARIOUS REGIONS[1]

Region	Land Used	
	Acres	Percent of Manitoba
Interlake	613,620	6.69
Eastern	936,140	10.21
Central	3,073,730	33.51
South West	3,034,321	33.08
North West	1,514,974	16.51
Manitoba	9,172,781	100

[1]Based on the model.

83.34 percent for rapeseed, 89.83 percent for rye, 36.84 percent for sunflowers, 54.51 percent for potatoes and 49.92 percent for sugarbeets in solution two than in solution one. Lower value of production of each crop was the result of lower prices and less acres allocated to most of the crops in solution two. All the regions also experienced a decrease in the total value of crops produced in solution two as compared to solution one. For example, total value of crops produced was lower by 82.21 percent in Interlake area, 90.21 percent in the Eastern region, 76.40 percent in the Central region, 74.01 percent in the South-West region and 79.90 percent in the North-West region in solution two. The South-West and Central regions observed the least decrease in the total value of crops as compared to the other regions due to the fact that optimal acreage also experienced the least decrease in these regions. The value of production of different crops in various regions in solution two is shown in Appendix C Table 51.

The value of net income in the analysis for 1976 in solution one came to \$689 million, whereas net income from crop production amounted to \$459 million under the actual conditions. In other words optimal level of net income in solution one was higher by 50.29 percent than the actual net income. The total number of farms in Manitoba was 32,106[116] in 1976. With that number of farms, average size of farm was 402 improved acres and average net income per farm came to \$14,288.52. Under optimum solution one conditions with farms of 760 improved acres, total number of farms came to 16,981 and average net incomer per farm amounted to \$40,621.11.

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[116] Manitoba Department of Agriculture, op. cit., p. 96

Net income per farm was higher under the optimal solution one as compared with the actual income because of the use of better production techniques, higher yields and reduced farm numbers.

Average net income per farm depends not only on the level of total net income, but also on the number of farms. A decrease in farm numbers causes average net farm income to increase even though the total net income was constant in Manitoba. If it was assumed that the efficient farms were of size 760 acres of improved land, then the efficient farm size was higher by 89.05 percent than the actual farm size in 1976. However, net income on these efficient farms was higher by 184.29 percent as compared to the actual average farm. This points out that net income per farm increases proportionately more than the increase in farm size under the 1976 conditions. This argument is dependent on and "efficient" size of 760 acres. Thus one can conclude that Manitoba agriculture has the potential to substantially increase the net earnings of the farmers if the farms were of economically efficient size and used the techniques employed by 760 and larger average farms in 1976. Although the aggregate income would increase substantially, but it would be shared by fewer farms.

Contribution of different regions towards the total net income is given in Table 74. This shows that Sout-West and Central regions were the most important in terms of their contribution to net income in optimal solution one. Individually, both of these regions contributed more than one-third of the total net income. The North-West region was next in importance followed by Eastern region. The Interlake region

TABLE 74

CONTRIBUTION OF DIFFERENT REGIONS
TOWARDS THE TOTAL NET INCOME IN SOLUTION ONE[1]

Region	Net Income in $	Percent of Total
Interlake	42,228,690	6.12
Eastern	57,009,448	8.27
Central	237,656,640	34.47
South West	245,051,690	35.54
North West	107,501,973	15.60
Total	689,448,461	100.00

[1]Based on the model.

shared only 6.12 percent of the total net income. This indicates that the contribution of different regions is more or less in the same proportion, as the total value of crop production shared among regions. In comparison with the actual percentage distribution of net income among regions as shown in Table 75, the Central and South-West regions contributed substantially more, while the other regions contributed proportionately less of the total net income in optimal solution one as compared with the actual net income.

The value of objective function in solution two was minus 62,329,818 dollars indicating the loss to the agriculture sector that would result if 1971 prices were used, even if the industry was organized efficiently. This was because of negative net income per acre associated with the production of most of the crops.

TABLE 75

ACTUAL CONTRIBUTION OF DIFFERENT REGIONS TOWARDS THE TOTAL NET INCOME[1]

Region	Net Income in $	Percent of Total
Interlake	34,400,180	7.50
Eastern	70,104,820	15.28
Central	112,350,300	24.49
South West	124,169,600	27.07
North West	117,722,460	25.66
Total	458,757,360	100.00

[1]Method of calculating the gross income is already discussed under Table 50. Actual cost of production of different crops was estimated by projecting the farm area from census reports for 1976 that would lie in three farm sizes (i.e. under 240 acre, 240 to 759 acres and over 759 acres). This was done because the cost of different components of production varied on various sized farms and due to the availability of cost data for these three sizes. Area of each crop on each size and soil type in 1976 in various crop districts was determined by weighing according to the percent area lying in various sizes and according to the percent distribution of land in two soil types. Cost per acre of different components with the exception of fertilizer and pesticides was determined as discussed in Chapter IV. For fertilizer and pesticide, cost per acre was taken from Framingham, Craddock and Baker op. cit. and then adjustment was done by their price indexes and by taking the increase in fertilizer sale and increase in cropped area treated.

CHAPTER VI

SUMMARY OF RESULTS AND CONCLUSIONS

As was mentioned in previous chapter, the second solution was obtained to see the workability and results of the model at other prices. For this reason, this chapter summarizes the results of solution one and the conclusions which can be drawn therefrom. This is followed by the implications of results for Manitoba. Finally the limitations of the present study and suggestions for future research are described.

Summary of Results

The optimal results of solution one obtained by applying the model to the data were compare with the actual and/or normal situations wherever possible. The results were discussed for the five agricultural regions and for Manitoba. For the province as a whole, total acres allocated to crops in the solution one were higher by 21 percent as compared to the actual acreage. Area occupied by wheat, potatoes and sugarbeets was lower in solution one than the actual acreage because of relatively high net income per acre from these crops over the previous years due to higher prices. The area allocated to rapeseed, sunflowers, and flaxseed was substantially higher than the actual acreage. Area occupied by oats, barley and rye was higher from 31.11 percent to 47.36 percent over the actual acreage. This was caused by the higher yields per acre used in this study than the actual yield and the substitution of area occupied by other crops for wheat, potatoes and sugarbeets.

At the regional level, the Central and South-West regions took the lead in the cropped acreage increase, where the total area occupied by crops was higher by 65.52 percent and 53.78 percent respectively over the actual acreage. As was explained in Chapter V, this was the result of higher net income per acre from most of the crops in these regions. In the Interlake area total optimal acreage was more or less the same as the actual acreage. A decrease in cropped area was experienced in the Eastern and North-West regions, where the solution one acreage was lower by about 23 percent as compared to the actual acreage in both regions. This was caused by the low net income per acre associated with most of the crops.

Total optimal acreage like the actual acreage, was not equally distributed among regions. The Central and South-West regions were the most important in terms of their contribution toward total optimal acreage in solution one. Individually both regions shared about one-third of the total optimal acreage, whereas they occupied 24.41 percent and 25.94 percent of the actual acreage. The North-West, Eastern and Interlake regions contributed less towards the total optimal acreage as compared to their contribution in the actual acreage. This was the result of high net income per acre from most of the crops in the Central and South-West regions, and low net income per acre in the other regions.

A comparison of the optimal solution one cropping pattern with the actual one indicated a significant difference. The percentage area occupied by wheat decreased considerably, while the relative area allocated to flaxseed, rapeseed and barley increased for the province. A similar trend was observed for each region.

It was observed that the optimum levels of production in solution one for all crops were higher than the actual and/or normal levels of production, with the exception of wheat and sugarbeets, whose optimum levels were lower than the actual levels. Low production of these crops was caused by the lessor number of acres allocated in the optimal sized farms solution. Higher levels of production of other crops as explained in Chapter V was caused by two factors:

1. more acres allocated to crops under the optimal solution, and
2. higher yield per acre of different crops in the model as compared to actual yield.

Considering the distribution of optimal production of crops among regions in solution one it was observed that the Central and South-West regions were making maximum contribution towards the total production of each crop. Collectively, both regions shared 60.03 percent to 91.48 percent of the total production of different crops. The North-West region contributed 1.75 percent to 17.72 percent of the total production of various crops. The Eastern and Interlake regions were the least important in terms of contribution towards total production. More concentration of the total production of various crops in the Central and South-West regions was the result of higher net income per acre associated with most of the crops in these regions. The percentage distribution of optimal and normal production of wheat, oats, barley, potatoes and sugarbeets among regions was more or less the same, while the optimal production of other crops was more concentrated in some regions and less concentrated in others. The percentage distribution of all crops with the exception of sunflowers, potatoes and sugarbeets was heavily concentrated in the Central and South-West regions in the optimal solution as compared with the actual production distribution.

Different regions have comparative advantage and disadvantage in the production of various crops as shown in Table 76.

The impact of efficient organization on the total labor requirement was also determined. Our model estimated total crop employment of 8,964 man years. The total employment was distributed among regions in more or less the same proportion as the distribution of total optimal acreage. Slight variations were caused by the difference in labor requirement of various crops.

The actual labor employment was more or less the same as under optimal solution one. The actual labor requirement would have been higher by 16 percent than the optimal solution one employment if the actual cropped acreage had been the same as optimal cropped acreage. However, both the optimal solution one and actual employment were substantially lower than the projected employment by the Manitoba Department of Industry and Commerce.[117] The distribution of employment was more concentrated in the Central and South-West regions in the optimal solution one where they contributed 35.06 percent and 30.33 percent of the total employment as compared to the actual distribution where they shared 26.34 percent and 25.21 percent, respectively. The North-West, Eastern and Interlake regions contributed less towards total optimal

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[117] Manitoba Department of Industry and Commerce op. cit., p. 27. Also see Footnote 114.

TABLE 76

COMPARATIVE ADVANTAGE AND DISADVANTAGE
IN THE PRODUCTION OF DIFFERENT
CROPS IN VARIOUS REGIONS

Region	Comparative Advantage	Comparative Disadvantage
Interlake		Wheat, oats, barley, flax, rapeseed, rye, sunflower, potatoes
Eastern	Oats, rapeseed	rye, sunflower, potatoes, sugarbeets
Central	Wheat, oats, barley, flax, rye, sunflower, potatoes, sugarbeets	
South West	rye, sunflower, potatoes	oats, flax, sugarbeets
North West	wheat, barley, rye	flax, sunflower, potatoes, sugarbeets

employment as compared to their contribution in the actual employment.

Optimal organization in solution one resulted in a total crop income of 1,170 million dollars which was higher by 36.52 percent and 52.31 percent as compared to the actual and normal income. The Central and South-West regions contributed individually more than 34 percent towards the total crop income, while the North-West, Eastern and Interlake regions contributed 15.64 percent, 9.22 percent and 6.35 percent respectively. Net income from the model amounted to about 690 million dollars which was higher by 50.29 percent than the actual level of income. The distribution of net income among regions was more or less in the same proportion as the total value of crop production among regions. With "efficient" farms of an average size of 760 acres, the net income per farm was higher by 184.29 percent than the actual average farm size, while the efficient farm size was greater by 89.05 percent than the actual farm size in 1976. Thus the net income per farm increased proportionately more than the increase in farm size. The Central and South-West regions were the most important in terms of their contribution toward net income in solution one. Individually both regions contributed more than one-third of the total net income, whereas they shared 24.49 percent and 27.07 percent of the actual net income. The North-West, Eastern and Interlake regions contributed less towards the total optimal net income as compared to their contribution in the actual net income. This was caused by higher net income per acre from most of the crops and more acreage cropped in the Central and South-West regions, and low net income per acre and lesser acreage in other regions.

Conclusions

A number of conclusions can be drawn from the result of this study. Some of the important conclusions are discussed here.

The first conclusion concerns the effect of optimal organization on the total cropped area and on the cropping pattern. The study indicated that the total cropped area was higher by 21 percent as compared to the actual area. Our model also showed a change in the cropping pattern, i.e. a decrease in the area devoted to wheat, potatoes and sugarbeet and an increase in the area allocated to other crops. Thus one could conclude that efficient organization would lead to not only an increase in the cropped area but would also substantially change the pattern of land use in Manitoba.

The increase in cropped area in the Central and South-West regions was so strong that it not only compensated for the decrease in area in Eastern and North-West regions, but also resulted in increasing total cropped area in Manitoba. From this it can be concluded that an optimal organization of the agriculture industry in Manitoba would require certain interregional adjustments in land use. The Central and South-West regions would become more important in terms of their contribution to total cropped area, while the share of the Eastern and North-West regions would decline.

Our results indicated that production of almost all the crops would increase with optimal organization. However this increase over the actual and normal production would not be proportionately the same for all crops. Production of certain crops would increase substantially more than other crops. This brings us to the conclusion that an efficient organization would lead to a disproportionate change in the production of crops.

The Central and South-West regions were the most important in terms of the area occupied by various crops. Correspondingly, these were also the most important in sharing the total production of various crops. Thus we could expect that although the contribution of these regions was already quite high in the actual production of various crops, they would contribute more towards the output of different crops in Manitoba with the optimal organization of agriculture. Other regions would experience an increase in the absolute production of most of the crops, but their share of total production would decline with efficient organization of agriculture because of the relative increase in the Central and South-West regions.

The optimal employment was more or less the same as the actual one. However, Central and South-West regions contributed considerably more towards total employment with optimal organization than with the actual one. This leads to the conclusion that Central and South-West regions would become more important in terms of their contribution to total employment, while the share of other regions would decline.

The results also indicated that the optimal organization of crop production along with the estimated requirement of livestock and poultry labor would need 21,118 man years which is much lower than the projected labor employment of 42,000 by the Department of Industry and Commerce.[118] This suggest that an efficient organization of agriculture would lead to the reduction of total amount of labor employment in crop production.

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[118] See Footnote 114.

Finally the results show that net income from crop production was greater by 50 percent when agriculture is organized efficiently in solution one as compared to the actual net income. This leads to the conclusion that an efficient agricultural industry using the best techniques of production would increase the net income of the farmers considerably.

The results also indicated that the contribution of Central and South-West regions towards the total net income was higher with the optimal organization as compared to the actual one. Thus one could expect that Central and South-West regions would experience an increase and other regions a decrease in sharing the total net income with an efficient organization.

Policy Implications

The cropping and production patterns specified for agriculture in solution one were optimal only under the conditions specified in the model. The study was concerned only with the economic analysis and did not say anything on social side. A number of policy implications can be derived from the results of this study ignoring the dangers associated with social aspect. Foremost among these is the great potential for increased output and net income from the crop production sector. Our results showed that net income from the crop production was higher by 50 percent han the actual net income. This result holds when crop production is organized on the optimum farms which are using the best techniques of production known in 1976. Profit per farm increased substantially because of reduced farm numbers and due to the efficient methods of production.

Given the objectives of Manitoba agriculture as specified in Chapter One, and the increased net income resulting from efficient organization of agriculture on the optimum sized farms, a basic question is, whether policies should be framed to convert the small farms into optimum units? Some will argue that an increase in net income from crop production is the only legitimate goal in measuring the benefits that will flow from an efficient organization of agriculture practised on the optimum sized farms. This group favors policies which would increase the total income from the agriculture sector. Others will argue the goal of maximization of positive utility of rural life on the family farms. They also advocate that the amalgamation of family farms into optimum sized farms leads to very high social cost and destroys the human values associated with them. This group favors farm policies which would increase the viability of small and medium farms. Thus the above two objectives which emphasize on the one hand an increase in total income from agriculture and on the other hand enhance the economic viability of low and middle income farmers are in direct conflict with each other. Neitherof the objectives can have dominance over the other because the society'spreference funciton is not linear and after achievement of one particular goal its further attainment involves diminishing utility relative to other goal. Expression of quantification of society' preference function is difficult especially with regard to an increase in income resulting from efficient use of resources in agriculture on the optimum sized farms and the existence of small family farms. Thus the decision about the extent to which the efficiency in use of resources in agriculture can be traded with the extent of existence of small family farms can be left ot politicians. Assuming that the Manitobans decide on an efficient use of resources in agriculture industry which could be practised on the optimum sized farms, then one could suggest the following-

1. Efficient use of resources requires an adjustment of farms towards optimum size. This size among other things is influenced by the government policies. The government policies which are conducive towards the viability of small farms would result in greater inefficiency in the agriculture sector. If there are no programs which support small farms and the economic forces in agriculture are allowed to work with little government interference, the farm numbers would decline rapidly and there would be an adjustment towardss the optimum farm size. Changes in government policies which favour the maintenance of small farms would be needed in order to achieve the necessary adjustments in farm size.

2. Co-operative farming would be offered by some as another possible approach. Small farmers which may not be able to justify the use of heavy machinery due to higher cost to individual farmers, may take advantage of the modern, large scale methods through co-operative farming and at the same time preserve the traditional values associated with the family farms. Through co-operative ownership of machinery, small farmers my realize economies of size and lower cost per unit of output and be able to compete with the large optimum sized farms. Reduced labor demand resulting from co-operative farming could be used for livestock operations or for some other industry. The government could provide necessary technical information and credit facilities to farmers who are interested in co-operative farming.

3. In case the government is concerned with the efficiency goal along with maintaining the family farms of optimum size, then the government should attempt to fashion two or more small undersized and inadequate family units into one large and more efficient unit, as land became available (rather than to add a small unit to an already large one). Institutions like Manitoba Agricultural Credit Corporation should be strengthened. A typical arrangement will be that as land comes into the market when the operator dies, retires or migrates, the Manitoba Agricultural Credit Corporation purchases it. The land so obtained can be sold to an operator of a smaller unit who is able to fashion a larger and more efficient unit through special credit arrangements. This will make a non-optimum sized farm into an optimum unit, rather than an increment to an already very large operation. Under this arrangement, the process of converting small farms into optimum units is very slow and gradual. If the Manitoba Agricultural Credit Corporation can pay higher price than the market, more farmers would like to move from farms to other industries. If in turn, the Manitoba Agricultural Credit Corporation can sell land below the market price and extend credit for a long term at a low interest rate, it can increase the demand by small farmers for land which would result in farm enlargement. The speed and effectiveness of this policy and its cost depends on the amount of public funds and assistance made available. If little emphasis is on the family farms then the Manitoba Agricultural Credit Corporation can sell small units to already large ones through special credit arrangements. This would assist and accelerate the process of enlargement by the absorption of those farms which are not of optimum size.

4. Optimum sized farms in Manitoba agriculture are of 760 acres and over, require machinery which is larger in size as compared to the machinery used by many farms today. This points out the adjustments which would be needed in the production of machinery in order to meet the demand on optimum sized farms.

5. In order to use the resources efficiently, optimum sized farms must use not only the better techniques of production but must also follow the cropping patterns which are most profitable to that region. These would require that necessary information about the profitability of crops and better techniques of production be provided to farmers through agricultural extension service.

6. Optimal organization of agriculture industry would result in

(a) increasing the production of all crops in all regions, and

(b) increasing the concentration of acreage and production in the Central and South-West regions as compared to other regions.

This provides us the information about the adjustment that should be made by agriculture if the net income from crop production is to be maximized. An increase and change in the distribution of acreage and production of various crops in different regions necessitates adjustments in the business serving agriculture.

7. The results indicated that the total cropped area would increase substantially in South-West and Central regions, while it would decline in the Eastern and North-West regions with an optimal organization of crop production. This would necessitate an adjustment in the cropped area. Retirement of land from crops in the North-West and Eastern regions would require the formulation of certain land diversion programs. This would

provincial industry strategy may wish to emphasize those regions more where there would not be sufficient employment opportunities and where more labor would be displaced with efficient organization of agriculture. Provision of employment opportunities at the regional level through industrialization could prevent the economic and social problems from falling particularly heavily on Winnipeg.

10. Due to seasonal nature of employment in crop production, total labor required in Central and South-West regions may exceed the labor available because of increase in crop acreage. This may require the movement of labor from other regions to Central and South-West regions. It would require that necessary incentives for migration of labor such as provision of moving expenses and better housing, education and health facilities be provided in the Central and South West regions by the government.

Limitations and Suggestions for Further Research

Our model can be used in a number of situations. Its ability to determine the efficient organization could also be improved in a number of ways. Its uses and ways of improvement are discussed here.

In the present study, we were concerned only with the determination of efficient organization of the important crops; we ignored some of the crops like tame hay, mixed grains, etc. Similarly, livestock production activities were omitted. Since the ignored activities are also users of the land resource in Manitoba, these activities should also be included in the determination of efficient organization on optimum sized farms in future studies. Inclusion of these activities would give precise information about the optimal organization of agriculture in Manitoba.

The model can also be used with variable demand restraints. Using various levels of demand restraints, one can determine the optimal solution. This can provide us the answer to what should be the optimal organization of agriculture with a change in projected demand.

The model could also be extended to all the provinces or the prairie provinces of Canada, which have comparative advantages in the production of various crops and/or livestock activities. Application of the model at the national level or to the prairie provinces could suggest how the use of resources should be shifted if the agriculture industry is primarily concerned with the maximization of its profits.

In this study complete certainty about the yields of crops was assumed. This was necessary because of small numbers of observations about the yields of crops at the recommended levels of fertilizer over time. Since the yields are greatly influenced by weather conditions, it is necessary to incorporate the risk associated with weather, while determining the efficient organization. This would be possible in the next few years, when more yield data with recommended levels of fertilizers under various weather conditons become available.

Efficient organizations with linear programming partial equilibrium model were determined under two price levels. Use of other prices could indicate the changes in optimal organization which would result from different levels of prices.

The optimum farm size determined by using the survivor approach, was assumed to be an efficient farm size for the present study. But the size optimum now may be non-optimal fifteen years later because of changes in technology, changes in resource availabilities and the like. When changes occur over time, their impact may be so strong that they may alter the optimum farm size. Determination of optimal organization of agriculture over time on efficient sized farms through the introduction of time element may be necessary in order to cover this dynamic aspect.

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APPENDIX A

MARGINAL ANALYSIS

MARGINAL ANALYSIS[119]

This analysis assumes that all functions have first and second partial derivatives. Considering the case where there are n products and m inputs, the production function can be stated in its implicit form as

$$F(y_1, y_2 \ldots . y_n; x_1, x_2 \ldots . x_m) = 0 \qquad (1)$$

WHERE $y_j \geqslant 0 \quad (j = 1, 2, 3 \ldots n)$ and

$x_i \geqslant 0 \quad (i = 1, 2 \ldots m)$

WHERE y_j denotes the quantity of j-th product produced and

x_i, the quantity of i-th input used.

The gross revenue can be given as

$$R = \sum_{j=1}^{n} p_j y_j \qquad (2)$$

WHERE p_j is the price per unit of commodity j.

The total cost can be given as

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[119]See: (1) Ralph W. Pfouts; "The Theory of Costs and Production in the Multiproduct Firm". Econometrica, Vol. 29, No. 4, October 1961, pp. 650-658.

(2) Thomas H. Naylor; "A Kuhn-Tucker Model of the Multi-product Multifactor Firm". Southern Economic Journal, Vol. 31, No. 4, April 1965, pp. 324-330.

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$$C = \sum_{i=1}^{m} v_i x_i + b$$

WHERE vi is the price of i-th input and b is the fixed cost.

Profit can be defined as

$$\pi = R - C$$

The Lagrangian method can be used to find the sets of y_j and x_i which maximize profit subject to the given production function. To do so form the function

$$L = \sum_{j=1}^{n} p_j y_j - \sum_{i=1}^{m} v_i x_i - b + \lambda F(y_1, y_2 \ldots y_n; x_1, x_2 \ldots x_m) \tag{3}$$

WHERE L is a function of all inputs and output regarded as independent variables and λ is a Lagrangian multiplier.

Using a single subscript of L, F, R and C to denote partial differentiation, the necessary conditions for profit maximization (i.e. n + m = K + 1 partial derivatives) are given by the following.

$$L_j = R_j + \lambda F_j = 0 \quad (j = 1, 2, \ldots n) \tag{4}$$

$$L_i = -C_i + \lambda F_i = 0 \quad (i = 1, 2 \ldots m) \tag{5}$$

$$L_\lambda = F(y_1, y_2 \ldots y_n; x_1, x_2 \ldots x_m) = 0 \tag{6}$$

Taking any two equations (e.g. a and b) from among the n equations of (4) and solving for λ, we get

$$\lambda = -\frac{R_a}{F_a}$$

$$\lambda = -\frac{R_b}{F_b}$$

equating these two expressions we get

$$\frac{R_a}{R_b} = \frac{F_a}{F_b} = -\frac{\partial y_b}{\partial y_a} \qquad (7)$$

This equation states that when optimum quantities of a and b are being produced the ratio of their marginal revenues must be equal to the physical rate of substitution between the two products.

If we select two equations from (5), among the m equations, we get

$$\lambda = \frac{C_a}{F_a} \quad \text{and}$$

$$\lambda = \frac{C_b}{F_b}$$

Equating these two expressions we get

$$\frac{C_a}{C_b} = \frac{F_a}{F_b} = -\frac{\partial x_b}{\partial x_a} \qquad (8)$$

This equation states that when optimum quantities of a and b are used in production, the ratio of their marginal costs must be equal to their rate of technical substitution.

Finally if we select one equation from the n equations in (4) and one equation from the m equations in (5) we get

$$C_a = R_b \frac{\partial y_b}{\partial x_a} \qquad (9)$$

which states that optimum quantity of factor a requires that the marginal factor cost of factor a to be equal to the marginal revenue product of b with respect to a.

Deriving the level of input and output by solving the first order conditions does not guarantee that the profit of the firm would be maximum. The same first order conditions will also satisfy a local minimum or a stationary value. The second order conditions for profit maximization requires that the bordered Hessian determinant alternate in sign:

$$\begin{vmatrix} \lambda F_{11} & \lambda F_{12} & F_1 \\ \lambda F_{21} & \lambda F_{22} & F_2 \\ F_1 & F_2 & 0 \end{vmatrix} > 0 \cdots\cdots (-1)^K \begin{vmatrix} \lambda F_{11} & \lambda F_{12} & \lambda F_{1K} & F_1 \\ \lambda F_{21} & \lambda F_{22} & \lambda F_{2K} & F_2 \\ & & & \\ \lambda F_{K1} & \lambda F_{K2} & \lambda F_{kk} & F_k \\ F_1 & F_2 & F_k & 0 \end{vmatrix} > 0 \qquad (10)$$

The most compact statement of the complete conditions for an optimal production schedule has been given by Hicks:

> "If the prices of all products and all factors are given to the enterprise, the quantities of factors it will employ, and products it will produce, will be given by the condition that surplus is maximum. This implies that it cannot be increased by any type of variation. We shall thus have the following conditions of equilibrium.
>
> 1. Corresponding to the condition Price = Marginal Cost, we have three conditions:
>
>   (a) The price ratio between any two factors must equal their marginal rate of substitution.
>
>   (b) The price ratio between any two products must equal the marginal rate of substitution between the two products.
>
>   (c) The price ratio between any factor and any product must equal the marginal rate of transformation between the factor and the product.

2. Next there are the stability conditions. For the transformation of a factor into a product we shall have the condition of diminishing marginal rate of transformation or diminishing marginal product. For the substitution of one product for another we shall have a condition of increasing marginal rate of substitution, that is to say, increasing marginal cost in terms of the other product (marginal opportunity cost). For the substitution of one factor for another diminishing marginal rate of substitution."[120]

The above quotation summarizes the results of the marginal analysis of the firm's production problem. The whole analysis depends on differentiating the production, revenue and cost functions with respect to each input and output independently, a mathematical procedure which has operational significance only when corresponding changes of values are possible.

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[120] J.R. Hicks, Value and Capital, Oxford University Press, 1941, pp. 86-87.

APPENDIX B

OPTIMALITY CONDITIONS OF LINEAR PROGRAMMING

OPTIMALITY CONDITIONS OF LINEAR PROGRAMMING[121]

Our problem which is concerned with the maximization of income of farmers from the limited resources can be formulated in terms of linear programming. Like the marginal analysis, consider the situation where a firm employs m variable factors and r fixed factors in the production of n independent activities. Then the firm's profit function can be given as

$$\pi = \sum_{j=1}^{n} p_j y_j - \sum_{i=1}^{m} \sum_{j=1}^{n} a_i \; X_{ij} - \sum_{v=1}^{r} \sum_{j=1}^{n} M_{vj} \; F_{vj} \qquad (1)$$

WHERE

π = Profit

p_j = The price of jth activity (j=1, 2, ... n)

y_j = The level of the jth activity (j=1, 2, . . . n)

121

(1) Robert Dorfman "Mathematical or 'Linear' programming. A non-mathematical exposition". The American Economic Review, Vol. 43, No. 5, Part 1; Dec. 1953, p. 797-825.

(2) Robert Dorfman; Application of Linear Programming to the Theory of Firm. A publication of the Bureau of Business and Economic Research, University of California, Published by University of California Press, Berkley and Los Angelos, 1951.

(3) Kenneth E. Boulding and Allen W. Spivey; Linear Programming and Theory of Firms. The Macmillan Company, New York, 1961.

(4) William J. Baumel; Economic Theory and Operations Analysis Parentice-Hall, Inc., Englewood Cliffs, New Jersey, 1972.

(5) William J. Banmel; "Activity Analysis in One Lesson". The American Economic Review, Vol. 43, No. 5, Dec. 1958, p. 837-873.

(6) Thomas H. Naylor; "The Theory of Firm. A Comparison of Marginal Analysis and Linear Programming". The Southern Economic Journal Vol. 32, No. 3, January 1966, p. 263-274.

(7) James M. Henderson and Richard E. Quandt; Micro-Economic Theory: A Mathematical Approach. McGraw-Hill Book Company Inc., New York.

a_i = The price of the ith variable input (i=1, 2, . . . m)

X_{ij} = Quantity of the ith variable input used by the jth activity (i=1.2 . . . m; j=1.2 . . . n)

M_{vj} = The cost of transfering one unit of vth fixed for use in jth activity (v=1, 2, . . . r; j=1, 2, . . . n)[122]

F_{vj} = The quantity of vth fixed factor used in jth activity (v=1, 2, . . . r; j=1, 2, . . . n)

Since an activity requires factors in certain proportion so the following constraints are imposed.

$$X_{ij} = a_{ij}\, y_j \quad (i=1, 2, \ldots m;\ j=1, 2, \ldots n) \qquad (2)$$

$$F_{vj} = b_{vj}\, y_j \quad (v=1, 2, \ldots r;\ j=1, 2, \ldots n) \qquad (3)$$

b_{vj} is the quantity of the vth fixed factor used by one unit of jth activity

The activity levels are also constrained by the availability of fixed resources, i.e.

$$\sum_{j=1}^{n} F_{vj} \leqslant F_v \qquad (v=1, 2, \ldots r) \qquad (4)$$

The Kuhn-Tucker Theorum could be used to describe the optimality conditions of functions constrained by equalities and inequalities. In order to apply the theorum, it is necessary that the objective function and constraints are concave. Since the objective function (1) and constraints (2, 3) are linear, the concavity requirements are fulfilled. The restraints in (4) are linear and may be considered as

[122]Pfouts has suggested that, "transferring units of fixed factors from the production of one product to that of another ordinarily entails a cost". This type of cost does not fall either the category of variable costs or fixed costs, for "these costs do not change continuously with the output of a particular product, but they do not change as the product mix of the firm is changed." Pfouts, op. cit., pp. 652-653.

both convex and concave. Hence the concavity requirements of the theorum are satisfied. The Lagrangian function of the firm's profit maximization can be given as

$$L = \sum_{j=1}^{n} p_j\, y_j - \sum_{i=1}^{m} \sum_{j=1}^{n} a_i\, X_{ij} - \sum_{v=1}^{r} \sum_{j=1}^{n} M_{vj}\, F_{vj} + \sum_{v=1}^{r} \lambda_v (F_v - \sum_{j=1}^{n} F_{vj})$$

$$+ \sum_{i=1}^{m} \sum_{j=1}^{n} u_{ij}\, (X_{ij} - a_{ij}\, y_j) + \sum_{v=1}^{r} \sum_{j=1}^{n} \delta_{ij} (F_{vj} - b_{vj}\, y_j) \qquad (2)$$

Following are the Kuhn-Tucker necessary and sufficient conditions for constrained maximum at y_j^*, X_{ij}^*, F_{vj}^*, λ^*_j, u_{ij}^* and δ^*_{vj}.

$$\frac{\partial L}{\partial y_j} = P_j - \sum_{i=1}^{m} u_{ij}\, a_{ij} - \sum_{v=1}^{r} \delta_{vj}\, b_{vj} \leqslant 0$$

or

$$P_j \leqslant \sum_{i=1}^{m} u_{ij}\, a_{ij} + \sum_{v=1}^{r} \delta_{vj}\, b_{vj} \qquad (j=1, 2, \ldots n) \qquad (3)$$

$$\frac{\partial L}{\partial X_{ij}} = -a_i + u_{ij} \leqslant 0$$

or

$$-a_i \leqslant - u_{ij} \qquad (i=1, 2, \ldots m;\ j=1, 2 \ldots n) \qquad (4)$$

$$\frac{\partial L}{\partial F_{vj}} = -M_{vj} - \lambda_v + \delta_{vj} \leqslant 0$$

or

$$\delta_{vj} - M_{vj} \leqslant \lambda_v \qquad (v=1, 2 \ldots r;\ j=1, 2 \ldots n) \qquad (5)$$

$$(P_j - \sum_{i=1}^{m} u_{ij}\, a_{ij} - \sum_{v=1}^{r} \delta_{vj} b_{vj})\, y_j^* + (-a_i + u_{ij})\, X_{ij}^* + (\delta_{vj} - M_{vj} - \lambda_j)\, F_{vj}^* = 0 \qquad (6)$$

$$y_j^* \geqslant 0 \qquad (j=1, 2 \ldots n) \qquad (7)$$

$$X^*_{ij} \geqslant 0 \qquad (i=1, 2 \ldots m; j=1, 2 \ldots n) \tag{11}$$

$$F^*_{vj} \geqslant 0 \qquad (v=1, 2 \ldots r; j=1, 2 \ldots n) \tag{12}$$

$$\frac{\partial L}{\partial \lambda_v} = F_v - \sum_{j=1}^{n} F_{vj} \geqslant 0$$

or

$$F_v \geqslant \sum_{j=1}^{n} F_{vj} \qquad (j=1, 2 \ldots n) \tag{13}$$

$$\frac{\partial L}{\partial \mu_{ij}} = X_{ij} - a_{ij}\, y_{ij} \geqslant 0$$

or

$$X_{ij} \geqslant a_{ij} y_{ij} \; (i=1, 2 \ldots m; j=1, 2 \ldots n) \tag{14}$$

$$\frac{\partial L}{\partial \delta_{vj}} = F_{vj} - b_{vj}\, y_j \geqslant 0$$

or

$$F_{vj} \geqslant b_{vj} y_j \qquad (v=1, 2 \ldots r; j=1, 2 \ldots n) \tag{15}$$

$$(F_v - \sum_{j=1}^{n} F_{vj}) \lambda^*_j + (X_{ij} - a_{ij}\, y_j) \mu^*_{ij} + (F_{vj} - b_{vj}\, y_j)\, {}^*_{vj} = 0$$

or

$$\sum_{v=1}^{r} \lambda^*_v \; F_v = \sum_{v=1}^{r} \sum_{j=1}^{n} \lambda^*_v \; F^*_{vj} \tag{16}$$

$$\lambda_j \geqslant 0 \qquad (j=1, 2 \ldots n) \tag{17}$$

$$\mu^*_{ij} \geqslant 0 \qquad (i=1, 2 \ldots m; j=1, 2 \ldots n) \tag{18}$$

$$\delta_{vj} \geqslant 0 \qquad (v=1, 2 \ldots r; j=1, 2 \ldots n) \tag{19}$$

In equation (5) λ_v, u_{ij} and δ_{ij} are the Lagrangian multipliers. These are the prices imputed to factors of production. i.e. the prices the firm would be willing to pay for the marginal unit of a particular factor. The marginal value imputed to the i-th variable input used in the j-th activity is shown by u_{ij}. The marginal value imputed to the v-th fixed factor is denoted by λ_v. The marginal value imputed to the v-th fixed factor used in the j-th activity is denoted by δ_{vj}.[123]

Equation (6) states that the price per unit of the j-th activity should be less than or equal to the sum of the imputed costs of the fixed and variable factors used in the production of one unit of j-th activity. If the market price of the j-th activity is less than the imputed costs of fixed and variable factors used per unit then that activity will not be used. If an activity is profitable, i.e. when the market price is greater than the imputed costs, then the linear programming solution will not be optimal and the profitable activity will be increased into the solution. If the market price of the j-th activity is equal to the imputed price of the fixed and variable factors used in production, then the j-th activity would be at the optimum level. Equation (6) corresponds to the marginal analysis in which optimality requires that marginal revenue be equated with marginal cost. If one could associate products with different activities, then one could find the rate of product transformation and marginal rate of substitution which are needed in finding the optimum quantities in marginal analysis.

Equation (7) states that the price of the i-th variable should be less than or equal to the marginal value imputed to the i-th variable factor used in the j-th activity. If the price of the i-th factor is greater than the marginal value imputed to the i-th variable factor used

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[123] Naylor, op. cit., p. 270.

in j-th activity, the factor will not be utilized by the j-th activity. If the price of the i-th factor is less than the marginal value imputed to the i-th variable factor used in j-th activity, then the level of usage of factor i in activity j should be increased. Variable factor i will be used at an optimum level in the j-th activity when the price of the i-th factor would be equal to the marginal value imputed to the i-th variable factor. This condition corresponds to marginal analysis which requires that the use of variable input should be increased to the point where value of the MP is equal to the price of the factor.

Condition (8) states that the marginal value imputed to the v-th fixed factor used in the j-th activity minus the cost of converting one unit of the v-th fixed factor for use in j-th activity should be less than or equal to the marginal value imputed to one unit of the v-th fixed factor. If the inequality holds, then the v-th fixed factor will not be used in the j-th activity. If equality holds, then the fixed factor is being used at an optimum level with regards to the j-th activity. If excess capacity exists in the v-th fixed factor, then $S_{vj} - V_{vj} = 0$.[124]

Equation (9) simply states that the firms profit after paying the imputed cost of factors must be zero.

Equations (10), (11) and (12) state that these terms cannot be negative. According to conditin (13) the total usage of v-th fixed factor cannot exceed the amount available. The equalities will hold for (14) and (15), since we defined them accordingly. Equation (16) states that the value imputed to the scarce resources available must be equal to total value of scarce resources used in the activities.

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[124] Ibid.

Equations (17), (18) and (19) state that the multipliers are nonnegative.

APPENDIX C

DATA AND SOME RESULTS

TABLE 1

Crop and Summerfallow Areas
In Different Crop Districts of Manitoba Over Time

	1961[a]		1966[b]		1971[c]	
Crop District	Crop Area	Summer-fallow	Crop Area	Summer-fallow	Crop Area	Summer-fallow
	acres					
1	645,103	343,703	748,327	259,225	756,165	261,285
2	714,230	318,188	800,720	249,292	846,634	233,715
3	1,470,831	422,949	1,676,852	271,018	1,718,073	241,056
4	264,740	89,730	295,176	66,440	303,166	66,150
5	897,832	235,816	913,245	218,474	957,833	174,183
6	145,638	27,686	136,289	35,611	144,736	26,830
7	502,072	282,683	585,679	229,574	596,071	242,537
8	571,874	237,196	642,494	194,040	676,394	168,172
9	463,408	225,769	518,086	198,308	543,669	195,374
10	642,433	442,956	761,250	389,721	787,360	442,927
11	542,407	280,971	621,652	245,451	669,620	259,833
12	296,626	75,727	343,518	78,216	419,612	84,910
13	289,416	132,198	345,071	120,438	355,094	140,134
14	242,118	114,523	305,323	113,022	348,047	118,091
	7,688,728	3,230,095	8,693,682	2,668,830	9,122,474	2,665,197

Source, [a]Dominion Bureau of Statistics, Census of Canada, Agriculture, Manitoba, Cat. No. 96-537, Queen's Printer, Ottawa, 1963.

[b]Dominion Bureau of Statistics, Census of Canada, Agriculture, Manitoba, Cat. No. 96-608, Queen's Printer, Ottawa, 1968.

[c]Statistics Canada, Census of Canada, Agriculture, Manitoba, Cat. No. 96-708, Queen's Printer, Ottawa, 1973.

TABLE 2

Production of Different Crops
in Manitoba Over Time

Year	Wheat	Rye	Rapeseed
	---------------Thousand bushels---------------		
1960	66,000	1,660	477
1961	34,000	886	360
1962	80,000	3,000	580
1963	61,000	2,128	760
1964	85,000	2,766	1,470
1965	79,000	2,992	2,407
1966	79,000	2,400	2,150
1967	90,000	2,667	2,300
1968	91,000	2,500	1,900
1969	64,000	3,358	3,500
1970	30,500	4,177	7,200
1971	74,000	3,280	12,000
1972	69,000	1,830	8,500
1973	80,000	2,145	7,700
1974	59,000	2,200	8,500

Source, Department of Agriculture, Yearbook of Manitoba Agriculture, Queen's Printer, Winnipeg, 1960-74.

TABLE 3

Acres Allocated to Sugarbeets, Sunflowers and Potatoes in Specific Crop Districts in 1976

Crop District	Sugarbeet	Sunflower	Potatoes
		acres	
1	--	2,955	--
2	22,858	20,187	13,941
3	4,373	1,154	301
4	3,802	2,181	2,091
5	--	3,984	--
6	--	--	--
7	--	9,823	5,601
8	--	7,969	9,697
9	645	--	682
10	958	--	1,187
11	300	349	891
12	--	--	113
13	--	989	--
14	--	--	--

Source, Statistics Canada, Census of Agriculture 1976.

TABLE 4

Use of Wheat, Oats and Barley as Feed in Canada

Year	Wheat	Oats	Barley
	-----------------bushels	---------------	
1960	62,293,272	349,160,228	138,023,756
1961	44,149,625	289,373,696	101,289,500
1962	44,203,777	370,184,798	92,826,824
1963	53,769,269	369,651,689	121,300,173
1964	46,878,730	352,989,816	134,360,316
1965	50,166,395	360,554,774	142,893,820
1966	52,789,047	361,980,456	177,486,047
1967	53,687,000	305,908,000	180,143,000
1968	64,197,000	282,639,000	199,449,000
1969	84,803,000	307,312,000	240,562,000
1970	79,203,000	340,412,000	247,999,000
1971	81,181,000	338,918,000	298,096,000
1972	75,721,000	309,399,000	297,211,000
1973	70,479,000	315,383,000	288,260,000
1974	62,440,000	239,301,000	244,283,000

Source; Statistics Canada, Grain Trade of Canada, Cat. No. 22-201, 1966-75.

TABLE 5

Livestock and Poultry in Canada
(in '000)

Year	Bulls	Milk Cows	Beef Cows	Yearling Heifers Dairy	Yearling Heifers Beef	Steers	Calves	Hogs	Sheep & Lambs	Horses	Hens & Pullets[d]
1960[a]	255.0	2,964.8	2,158.8	735.6	793.9	1,237.5	3,191.4	5,070	1,607	552	
1961[a]	257.5	2,986.8	2,341.0	749.7	856.7	1,397.5	3,344.6	5,331	1,548	511	7,668.5
1962[a]	253.2	2,938.5	2,437.0	726.4	868.1	1,455.1	3,388.7	4,981	1,449	478	6,744.0
1963[a]	258.1	2,873.0	2,579.3	727.1	954.5	1,483.2	3,489.8	5,211	1,346	451	6,653.0
1964[a]	263.0	2,845.0	2,830.1	706.5	1,079.0	1,675.4	3,595.0	5,667	1,272	431	6,799.0
1965[a]	269.7	2,795.0	3,035.0	665.8	1,102.1	1,723.4	3,669.0	5,147	1,132	403	7,942.0[d]
1966[a]	253.2	2,673.9	2,987.0	615.5	1,027.3	1,751.8	3,570.1	5,401	1,006	386	8,967.9
1967[a]	256.2	2,569.0	2,995.6	594.2	1,104.6	1,715.4	3,462.0	6,070	922	370	8,757.5
1968[a]	247.3	2,489.0	2,967.0	598.2	1,087.8	1,734.0	3,363.7	5,771	829	360	8,255.6
1969[a]	244.2	2,442.0	2,983.0	597.0	1,098.6	1,702.2	3,299.0	5,809	796	359	8,458.0
1970[a]	241.4	2,389.0	3,176.6	572.4	1,203.9	1,750.5	3,492.2	7,114	796	358	9,358.0
1971[a]	257.6	2,255.1	3,514.2	560.6	1,295.5	1,720.9	3,666.7	7,624	851	354	9,540.0
1972[a]	259.3	2,210.8	3,679.4	524.3	1,419.0	1,762.1	3,801.6	6,995	845	350	
1973[a]	270.0	2,152.0	3,940.6	539.8	1,419.5	1,777.8	4,033.8	7,022	833	342	
1974[b]	295.0	2,080.0	4,255.5	550.6	1,541.1	1,995.6	4,260.7	6,564	783.5		
1975[c]	238.7	2,085.0	4,293.3	514.9	1,179.4	1,449.4	4,247.3	5,895.0	541.3		

[a]Statistics Canada, Handbook of Agricultural Statistics Livestock and Animal Products, Part VI, Cat. 21-514, Occasional, 1871-1973, Nov. 1974.

[b]Statistics Canada, Quarterly Bulletin of Agricultural Statistics, Cat. 21-003, July-Sept. 1974.

[c]Statistics Canada, Quarterly Bulletin Agr. Statistics, Cat. 21-003, Jan.-March 1976

[d]Statistics Canada Cat. No. 23-202.

TABLE 6

Livestock Numbers in Crop District 1 Over Time

Year.	Bulls	Milk Cows & Heifers Over 2 yrs.	Beef Cows & Heifers Over 2 yrs.	Milk Heifers 1-2 yrs.	Beef Heifers 1-2 yrs.	Steers	Calves	Hogs		Sheep	
								6 mo. & Older	Under 6 mo.	Over 1 Yr.	Under 1 Yr.
1963	1,300	5,400	26,700	800	7,900	9,500	27,200	3,000	12,500	3,500	3,700
1964	1,300	5,300	29,700	1,100	8,800	12,200	29,000	5,000	13,000	3,500	3,400
1965	1,100	5,300	31,000	1,000	10,500	12,700	31,300	4,500	10,500	3,000	2,700
1966	900	5,100	28,000	1,100	10,500	11,500	29,000	5,500	11,500	2,300	1,700
1967	1,400	4,100	30,400	400	8,800	12,500	27,700	4,500	12,000	1,000	1,100
1968	1,200	4,300	27,000	400	6,700	10,200	28,500	4,000	9,000	700	600
1969	1,100	3,400	26,000	300	6,000	12,000	26,000	6,000	14,000	700	600
1970	1,300	4,000	28,000	400	7,300	12,000	29,000	6,000	19,000	700	600
1971	1,200	4,200	33,000	400	7,700	10,000	31,000	6,000	21,000	1,000	1,000
1972	1,600	2,800	31,000	600	9,300	12,500	28,500	4,500	21,500	1,000	800
1973	1,600	2,700	35,000	600	8,500	12,000	31,000	4,200	20,800	900	700
1974	1,700	2,600	39,000	500	9,800	14,000	34,000	4,500	23,500	700	500
1975	1,700	2,600	39,000	400	10,500	16,000	35,000			500	400

Source, Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Winnipeg, Queen's Printer, 1963-75.

TABLE 7

Livestock Numbers in Crop District 2 Over Time

Year	Bulls	Milk Cows & Heifers Over 2 yr.	Beef Cows & Heifers Over 2 yr.	Milk Heifers 1-2 yr.	Beef Heifers 1-2 yr.	Steers	Calves	Hogs 6 mo. & Older	Hogs Under 6 mo.	Sheep Over 1 Yr.	Sheep Under 1 Yr.
1963	2,100	11,200	30,300	2,400	10,200	11,700	35,400	10,400	25,600	3,200	3,300
1964	2,300	11,000	35,300	2,600	10,600	13,900	34,000	13,000	37,000	3,800	3,100
1965	2,100	10,400	38,000	2,300	10,100	11,600	36,600	15,000	31,000	2,600	2,600
1966	1,900	9,500	33,000	2,400	7,700	12,100	32,500	19,000	36,000	2,400	2,600
1967	1,700	8,000	33,400	1,200	9,500	10,700	33,000	16,000	50,000	1,100	1,200
1968	1,600	7,300	33,000	1,100	8,000	10,200	34,500	15,500	44,500	700	700
1969	1,600	7,000	31,000	800	7,600	12,000	35,000	19,000	48,000	700	800
1970	1,700	5,600	32,000	700	8,000	12,000	38,000	26,000	79,000	900	800
1971	1,700	6,000	38,000	800	11,700	12,000	39,000	27,000	88,000	1,000	1,200
1972	1,800	7,000	36,000	1,400	10,500	18,000	30,500	25,000	83,000	1,300	1,000
1973	1,900	6,600	37,000	1,300	11,000	16,000	31,000	29,000	83,000	1,100	900
1974	2,100	6,300	41,000	1,300	12,200	18,500	34,000	29,000	80,000	800	600
1975	2,300	6,200	41,000	1,500	13,200	19,000	35,000			700	600

Source, Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Winnipeg, Queen's Printer, 1963-75.

TABLE 8

Livestock Numbers in Crop District 3 Over Time

Year	Bulls	Milk Cows & Heifers Over 2 yr.	Beef Cows & Heifers Over 2 yr.	Milk Heifers 1-2 yr.	Beef Heifers 1-2 yr.	Steers	Calves	Hogs		Sheep	
								6 mo. & Older	Under 6 mo.	Over 1 Yr.	Under 1 yr.
1963	1,800	19,800	18,900	5,100	5,400	15,000	26,000	21,000	62,000	2,300	3,100
1964	1,800	19,300	20,300	5,100	5,700	15,000	25,000	24,000	71,000	2,400	2,800
1965	2,100	18,700	20,700	4,100	5,600	13,400	24,800	24,500	65,500	1,900	2,000
1966	2,100	16,200	18,100	3,400	4,600	16,000	22,200	27,300	73,700	1,300	1,600
1967	1,400	15,000	18,200	3,300	7,000	11,500	20,000	39,000	103,000	1,600	1,700
1968	1,200	14,500	17,000	3,400	4,700	12,000	20,500	30,000	90,000	1,500	1,500
1969	1,300	13,600	16,500	3,000	5,900	15,000	18,000	36,000	94,000	1,400	1,300
1970	1,400	13,400	19,000	2,700	8,100	20,000	19,000	43,000	135,000	1,600	1,400
1971	1,200	13,400	23,000	2,500	9,000	20,500	21,000	35,000	100,000	2,100	2,100
1972	1,400	13,500	20,500	3,500	7,600	16,000	24,000	46,000	144,000	2,800	1,800
1973	1,500	13,000	21,000	3,600	7,500	12,500	24,000	42,000	145,000	2,800	1,900
1974	1,800	13,300	24,000	3,600	7,300	13,500	27,000	28,000	117,000	2,300	1,600
1975	1,800	13,300	24,000	3,700	7,900	14,000	28,000			2,000	1,500

Source; Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Winnipeg, Queen's Printer, 1963-75.

TABLE 9

Livestock Numbers in Crop District 4 Over Time

Year	Bulls	Milk Cows & Heifers Over 2 yr.	Beef Cows & Heifers Over 2 yr.	Milk Heifers 1-2 yr.	Beef Heifers 1-2 yr.	Steers	Calves	Hogs 6 mo. & Older	Hogs Under 6 mo.	Sheep Over 1 yr.	Sheep Under 1 yr.
1963	500	8,300	6,000	2,800	3,500	3,400	9,200	11,800	15,600	700	900
1964	600	8,000	7,800	3,500	2,000	5,000	10,000	11,000	14,000	500	600
1965	700	8,000	7,400	3,400	1,400	3,300	10,800	12,000	13,000	300	300
1966	900	7,400	8,100	3,400	1,200	4,100	9,000	18,000	11,000	300	300
1967	600	8,500	9,500	2,200	3,800	5,700	9,800	8,000	22,000	800	700
1968	500	7,700	10,000	1,800	3,600	4,400	9,500	8,000	18,000	900	700
1969	400	7,400	8,000	1,500	4,000	4,400	10,000	10,000	23,000	1,000	800
1970	500	7,800	9,000	1,400	4,000	6,000	11,000	10,000	25,000	1,200	800
1971	600	9,000	11,000	1,200	3,200	5,600	12,000	11,000	26,000	1,200	1,300
1972	500	7,000	10,500	2,400	4,200	5,800	9,000	12,000	38,000	1,100	700
1973	600	7,000	12,000	2,400	3,800	5,500	11,000	12,000	39,000	1,000	800
1974	600	6,900	13,000	2,400	4,000	6,500	13,000	10,000	38,000	800	600
1975	500	6,200	13,000	2,100	4,300	6,000	13,000			700	500

Source: Manitoba Department of Agriculture Manitoba Agriculture Yearbook, Winnipeg, Queen's Printer, 1963-75.

TABLE 10

Livestock Numbers in Crop District 5 Over Time

Year	Bulls	Milk Cows & Heifers Over 2 yr.	Beef Cows & Heifers Over 2 yr.	Milk Heifers 1-2 yr.	Beef Heifers 1-2 yr.	Steers	Calves	Hogs 6 mo. & older	Hogs Under 6 mo.	Sheep Over 1 yr.	Sheep Under 1 yr.
1963	2,100	35,800	9,700	8,400	3,600	12,000	30,500	13,000	52,000	1,800	2,000
1964	2,100	36,000	12,300	8,100	4,300	9,500	33,000	16,500	57,500	1,900	1,700
1965	2,100	35,600	13,200	7,900	4,000	9,000	32,400	15,500	58,500	1,100	900
1966	1,900	35,000	14,000	7,900	2,800	8,500	30,500	15,000	65,000	1,100	1,000
1967	1,900	31,000	12,000	9,000	5,300	14,600	24,000	25,000	74,000	1,600	1,700
1968	1,500	28,00	11,500	9,000	4,100	10,800	23,500	27,000	72,000	1,300	1,000
1969	1,600	25,500	11,000	8,500	4,200	10,000	25,000	29,000	73,000	1,300	1,200
1970	1,700	23,700	12,000	7,800	6,300	12,500	27,000	23,000	112,000	1,600	1,900
1971	1,400	25,000	15,000	7,800	6,300	14,500	28,000	28,000	122,000	2,000	2,000
1972	1,500	25,500	14,500	7,000	7,500	9,800	22,000	34,000	121,000	1,700	1,300
1973	1,600	25,000	16,000	7,200	6,000	11,000	22,000	41,000	141,000	1,500	1,200
1974	1,600	25,000	18,000	7,200	6,500	13,000	27,000	42,000	133,000	1,500	1,100
1975	1,900	25,200	18,000	7,200	7,000	14,000	27,000			1,700	1,100

Source, Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Winnipeg, Queen's Printer, 1963-75.

TABLE 11

Livestock Numbers in Crop District 6 Over Time

Year	Bulls	Milk Cows & Heifers Over 2 yr.	Beef Cows & Heifers Over 2 yr.	Milk Heifers 1-2 yr.	Beef Heifers 1-2 yr.	Steers	Calves	Hogs 6 mo. & over	Hogs Under 6 mo.	Sheep Over 1 yr.	Sheep Under 1 yr.
1963	1,000	9,600	3,200	3,000	1,500	2,500	10,500	1,500	3,000	1,700	1,800
1964	1,100	9,800	4,500	2,600	1,400	2,500	11,000	3,000	5,000	1,600	1,600
1965	1,100	9,200	4,500	2,300	1,600	3,000	11,000	2,500	4,000	1,000	1,000
1966	1,000	9,200	3,800	2,300	1,200	2,800	10,700	3,000	5,500	1,000	1,000
1967	900	8,400	6,000	2,200	2,800	3,200	10,000	1,500	8,500	800	700
1968	800	8,200	5,500	2,000	2,800	3,000	8,500	2,000	6,500	600	600
1969	700	7,500	5,500	1,700	2,500	2,500	9,000	2,000	8,000	700	900
1970	700	8,000	6,400	1,300	2,900	3,500	10,000	2,000	8,000	700	900
1971	800	8,400	8,800	1,600	4,000	3,500	12,000	3,000	8,000	800	900
1972	700	5,000	9,000	1,000	2,700	2,600	9,500	3,600	8,900	600	400
1973	800	4,700	10,000	1,100	2,700	2,500	10,000	4,000	11,000	500	400
1974	900	4,500	11,000	1,100	3,000	3,500	12,000	4,300	12,700	400	300
1975	1,000	4,400	11,000	1,200	3,200	5,000	12,000			300	200

Source; Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Winnipeg, Queen's Printer, 1963-75.

TABLE 12

Livestock Numbers in Crop District 7 Over Time

Year	Bulls	Milk Cows & Heifers Over 2 yr.	Beef Cows & Heifers Over 2 yr.	Milk Heifers 1-2 yr.	Beef Heifers 1-2 yr.	Steers	Calves	Hogs		Sheep	
								6 mo. & Older	Under 6 mo.	Over 1 yr.	Under 1 yr.
1963	1,500	9,000	24,000	3,000	7,500	8,300	26,700	2,500	11,200	3,400	2,700
1964	1,600	9,100	27,800	2,000	6,700	7,000	30,000	3,500	12,000	3,300	2,400
1965	1,800	9,200	30,000	2,000	7,400	7,200	26,300	3,500	9,000	3,000	2,800
1966	1,500	9,500	27,700	1,700	7,900	7,600	27,000	4,000	16,000	2,500	1,600
1967	1,500	5,700	31,500	1,000	7,400	11,400	28,000	7,000	22,000	1,600	1,500
1968	1,400	3,700	31,500	900	5,000	8,100	25,500	6,000	20,000	2,000	1,900
1969	1,500	3,400	31,000	900	7,000	8,000	26,000	6,500	22,500	2,000	2,000
1970	1,600	3,000	35,000	700	7,600	13,530	26,000	16,000	27,000	2,300	2,000
1971	1,800	3,000	40,000	500	8,700	13,500	29,000	15,000	34,000	2,300	2,200
1972	1,700	4,600	35,500	700	11,000	12,500	33,000	9,400	28,600	1,700	1,300
1973	1,900	4,400	37,000	700	12,500	12,000	33,000	10,000	28,000	1,600	1,300
1974	2,100	4,200	38,000	700	14,500	12,000	35,000	6,000	14,000	1,200	800
1975	2,300	4,400	39,000	1,000	15,700	14,000	37,000			900	800

Source; Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Winnipeg, Queen's Printer, 1963-75.

TABLE 13

Livestock Numbers in Crop District 8 Over Time

Year	Bulls	Milk Cows & Heifers Over 2 yr.	Beef Cows & Heifers Over 2 yr.	Milk Heifers 1-2 yr.	Beef Heifers 1-2 yr.	Steers	Calves	Hogs		Sheep	
								6 mo. & Older	Under 6 mo.	Over 1 yr.	Under 1 yr.
1963	1,500	9,800	26,000	2,000	8,600	10,000	25,900	4,000	20,000	1,500	2,100
1964	1,700	10,000	30,400	2,200	7,600	12,200	28,000	6,500	21,000	1,300	1,400
1965	1,600	10,200	30,800	2,100	7,000	12,500	27,600	6,000	17,000	1,400	1,200
1966	1,300	9,800	27,200	2,100	9,300	9,700	26,200	7,400	25,600	1,200	900
1967	1,300	8,200	24,500	1,800	6,500	13,500	25,000	10,000	26,000	1,600	1,500
1968	1,200	8,200	24,000	1,800	4,500	13,500	22,000	10,000	23,000	1,500	1,400
1969	1,200	7,100	24,000	1,600	4,000	14,000	21,000	10,000	25,000	1,600	1,400
1970	1,400	6,600	25,000	1,500	4,800	13,500	27,000	12,000	48,000	1,800	1,400
1971	1,400	7,000	27,000	1,200	5,300	12,900	28,000	12,000	37,000	2,400	2,300
1972	1,600	6,400	29,000	1,500	9,500	18,000	27,500	13,000	54,000	2,200	1,300
1973	1,700	6,200	31,000	1,600	9,000	15,000	28,000	12,000	51,000	2,100	1,300
1974	1,900	6,200	32,000	1,700	12,000	18,000	30,000	11,500	42,500	1,700	1,200
1975	2,000	6,300	33,000	2,100	13,000	18,000	32,000			1,600	1,200

Source; Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Winnipeg, Queen's Printer, 1963-75.

TABLE 14

Livestock Numbers in Crop District 9 Over Time

Year	Bulls	Milk Cows & Heifers Over 2 yr.	Beef Cows & Heifers Over 2 yr.	Milk Heifers 1-2 yr.	Beef Heifers 1-2 yr.	Steers	Calves	Hogs 6 mo. & Older	Hogs Under 6 mo.	Sheep Over 1 yr.	Sheep Under 1 yr.
1963	1,300	8,500	19,200	1,900	8,100	10,200	20,100	8,400	17,400	2,600	2,800
1964	1,600	8,500	22,000	1,900	7,500	10,600	22,500	8,500	20,500	2,300	2,300
1965	1,600	7,500	23,500	1,600	7,300	7,300	24,100	8,500	21,500	2,000	2,200
1966	1,700	7,500	21,700	1,600	5,900	8,300	22,000	11,000	23,000	1,600	2,000
1967	1,100	7,000	24,500	1,300	5,500	8,300	22,000	9,000	25,000	1,100	1,200
1968	1,000	6,000	22,000	1,200	6,000	6,000	19,700	9,000	21,000	1,100	1,100
1969	1,100	5,700	22,000	900	5,500	7,600	18,500	8,000	24,000	1,100	1,100
1970	1,000	5,900	23,000	700	5,700	8,000	19,500	10,000	55,000	1,500	1,300
1971	1,300	5,800	25,000	800	6,000	8,000	22,000	15,000	60,000	1,900	1,500
1972	1,200	4,500	28,000	800	5,800	9,400	23,500	11,500	43,500	700	600
1973	1,200	4,300	30,000	800	5,500	8,000	25,000	11,000	45,000	700	600
1974	1,300	4,300	31,000	800	6,500	11,000	23,000	13,000	47,000	600	400
1975	1,400	5,100	29,000	800	7,000	12,000	23,000			500	300

Source; Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Winnipeg, Queen's Printer, 1963-75.

TABLE 15

Livestock Numbers in Crop District 10 Over Time

Year	Bulls	Milk Cows & Heifers Over 2 yr.	Beef Cows & Heifers Over 2 yr.	Milk Heifers 1-2 yr.	Beef Heifers 1-2 yr.	Steers	Calves	Hogs 6 mo. & Older	Hogs Under 6 mo.	Sheep Over 1 Yr.	Sheep Under 1 Yr.
1963	2,200	13,300	32,400	2,900	8,500	10,500	33,500	6,700	15,000	2,300	2,800
1964	2,500	12,800	35,700	2,900	10,300	11,300	34,000	7,500	19,500	2,200	2,300
1965	2,300	11,400	37,500	2,200	9,000	13,000	36,400	6,000	16,000	2,200	2,100
1966	2,000	11,500	32,000	2,100	7,900	13,000	30,500	7,400	16,600	2,000	2,400
1967	2,100	8,300	35,500	1,600	9,300	11,000	33,000	6,000	21,000	1,400	1,600
1968	2,000	7,600	35,000	1,600	8,300	8,200	37,000	7,000	21,000	1,500	1,500
1969	2,100	8,600	33,000	1,500	10,000	12,000	33,500	10,000	30,000	1,600	1,800
1970	1,900	9,000	38,000	1,000	11,600	16,500	36,000	21,000	49,000	2,000	3,300
1971	2,000	8,500	42,000	1,200	11,700	14,000	38,500	14,000	38,000	2,500	2,300
1972	2,800	6,900	44,000	1,100	11,800	14,500	35,000	10,000	32,000	1,300	1,100
1973	2,600	6,400	45,000	1,100	11,000	12,500	37,000	10,000	33,000	1,300	1,100
1974	2,800	6,300	48,000	1,000	10,800	12,500	39,000	7,000	20,000	800	600
1975	3,000	6,500	47,000	800	11,700	14,000	39,000			700	500

Source; Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Winnipeg, Queen's Printer, 1963-75.

TABLE 16

Livestock Numbers in Crop District 11 Over Time

Year	Bulls	Milk Cows & Heifers Over 2 yr.	Beef Cows & Heifers Over 2 yr.	Milk Heifers 1-2 yr.	Beef Heifers 1-2 yr.	Steers	Calves	Hogs 6 mo. & Older	Hogs Under 6 mo.	Sheep Over 1 yr.	Sheep Under 1 yr.
1963	1,700	15,200	19,200	3,400	4,800	8,700	28,200	5,300	15,700	2,300	2,400
1964	1,700	14,200	23,400	4,100	5,500	8,800	31,000	6,500	21,500	2,200	2,200
1965	1,700	14,500	23,400	4,000	4,900	6,600	31,900	5,500	16,500	3,000	2,700
1966	1,500	13,400	23,500	3,200	6,000	11,400	31,000	4,500	17,500	2,800	3,200
1967	1,700	9,500	29,000	1,800	9,500	11,300	27,000	6,000	20,000	2,900	2,800
1968	1,600	9,300	29,000	1,900	6,500	10,500	26,500	5,000	21,000	2,200	2,200
1969	1,500	7,900	30,000	1,300	5,700	9,500	28,000	7,000	29,000	2,300	2,000
1970	1,700	8,100	32,600	1,200	8,400	10,000	32,000	9,000	33,000	2,700	3,600
1971	1,300	6,500	33,500	1,000	9,300	8,000	34,000	7,000	29,000	3,100	3,000
1972	2,000	6,100	33,500	900	10,500	10,500	29,500	9,000	42,000	2,200	1,600
1973	2,100	5,900	35,000	900	9,000	9,500	33,000	10,000	43,000	2,200	1,700
1974	2,200	5,800	39,000	900	10,500	10,500	36,000	8,500	38,500	1,700	1,200
1975	2,600	5,600	38,000	800	11,300	11,000	35,000			1,400	1,000

Source; Manitoba Department of Agriculture, <u>Manitoba Agriculture Yearbook</u>, Winnipeg, Queen's Printer, 1963-75.

TABLE 17

Livestock Numbers in Crop District 12 Over Time

Year	Bulls	Milk Cows & Heifers Over 2 yr.	Beef Cows & Heifers Over 2 yr.	Milk Heifers 1-2 yr.	Beef Heifers 1-2 yr.	Steers	Calves	Hogs 6 mo. & Older	Hogs Under 6 mo.	Sheep Over 1 yr.	Sheep Under 1 yr.
1963	2,100	20,800	31,000	6,000	6,600	12,700	28,500	3,000	12,900	3,600	3,900
1964	2,400	22,200	34,900	5,200	7,400	14,000	32,000	3,000	13,000	3,200	3,300
1965	2,500	21,400	37,600	4,900	7,900	14,500	35,200	4,000	10,000	2,900	2,800
1966	2,400	19,300	38,000	5,400	7,500	14,700	35,700	3,400	12,600	2,200	1,800
1967	2,200	17,000	42,500	4,000	10,100	19,000	36,000	5,000	15,000	1,800	1,700
1968	2,100	17,000	39,500	3,200	10,000	19,500	33,500	4,000	16,000	1,400	1,300
1969	2,100	15,900	40,000	2,900	9,000	16,000	33,000	4,000	14,000	1,400	1,300
1970	2,100	14,400	42,000	3,500	11,100	21,000	36,500	8,000	18,000	1,700	2,000
1971	2,200	14,600	46,000	3,800	12,200	18,000	38,000	8,000	16,000	2,200	2,200
1972	2,300	10,700	50,000	2,500	13,000	13,700	42,000	7,000	22,500	1,600	1,500
1973	2,200	10,000	54,000	2,600	12,000	11,000	44,000	8,000	26,000	1,600	1,500
1974	2,400	9,900	60,000	2,600	13,500	13,500	50,000	6,500	21,500	1,100	800
1975	2,700	10,000	62,000	2,400	14,600	15,000	53,000			800	700

Source; Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Winnipeg, Queen's Printer, 1963-75.

TABLE 18

Livestock Numbers in Crop District 13 Over Time

Year	Bulls	Milk Cows & Heifers Over 2 yr.	Beef Cows & Heifers Over 2 yr.	Milk Heifers 1-2 yr.	Beef Heifers 1-2 yr.	Steers	Calves	Hogs 6 mo. & Older	Hogs Under 6 mo.	Sheep Over 1 yr.	Sheep Under 1 yr.
1963	800	5,500	8,800	1,300	2,400	3,400	10,200	4,300	16,800	2,400	2,300
1964	1,000	5,400	9,600	1,200	3,000	5,000	10,000	6,500	18,500	2,100	2,000
1965	900	5,100	10,700	1,100	2,200	4,700	11,600	5,500	13,500	1,500	1,400
1966	600	4,400	10,900	800	3,400	4,000	10,200	9,500	19,000	1,100	1,400
1967	800	3,800	10,000	700	3,200	4,600	10,500	7,000	23,000	1,000	1,000
1968	700	3,500	10,000	600	2,800	3,100	8,600	9,000	16,000	800	800
1969	600	3,400	9,000	500	2,200	4,000	8,000	11,000	24,000	600	700
1970	800	3,100	10,000	700	2,500	6,500	9,500	19,000	31,000	700	800
1971	700	2,700	10,700	900	3,200	6,500	8,000	15,000	45,000	1,100	1,000
1972	600	2,000	11,500	300	4,100	5,200	11,000	9,500	27,500	500	500
1973	600	1,600	13,000	300	4,500	5,000	12,000	10,000	34,000	500	500
1974	600	1,700	14,000	300	4,400	5,000	12,000	7,500	25,500	400	300
1975	700	1,600	14,000	300	4,800	7,000	12,000			300	200

Source; Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Winnipeg, Queen's Printer, 1963-75.

TABLE 19

Livestock Numbers in Crop District 14 Over Time

Year	Bulls	Milk Cows & Heifers Over 2 yr.	Beef Cows & Heifers Over 2 yr.	Milk Heifers 1-2 yr.	Beef Heifers 1-2 yr.	Steers	Calves	Hogs 6 mo. & Older	Hogs Under 6 mo.	Sheep Over 1 yr.	Sheep Under 1 yr.
1963	1,100	9,800	19,600	3,000	4,400	7,100	21,100	5,100	5,300	3,700	4,200
1964	1,300	10,400	20,300	3,500	5,200	10,000	21,500	5,500	6,500	3,700	4,000
1965	1,400	9,500	23,700	3,100	5,100	9,200	25,000	4,000	5,000	3,100	3,300
1966	1,300	9,200	22,000	2,600	4,100	7,300	25,500	5,000	7,000	2,200	1,500
1967	1,400	7,500	35,000	1,500	7,300	7,700	29,000	4,000	8,500	4,500	4,600
1968	1,200	7,700	33,000	1,100	6,000	5,500	26,200	3,500	8,000	4,800	4,700
1969	1,200	6,600	33,000	600	6,400	5,000	29,000	6,500	18,500	4,600	4,100
1970	1,200	5,400	36,000	400	7,700	10,000	29,500	10,000	30,000	4,600	2,200
1971	1,400	4,900	43,000	300	8,700	8,000	29,500	8,000	22,000	4,400	4,000
1972	1,800	4,000	41,000	800	9,500	7,500	32,000	6,500	8,500	3,300	2,100
1973	1,700	4,200	44,000	800	9,000	7,500	34,000	6,800	10,200	3,200	2,100
1974	2,000	4,000	47,000	900	10,000	8,500	38,000	2,200	6,800	3,000	2,000
1975	2,100	4,600	47,000	700	10,800	10,000	40,000			2,900	2,000

Source: Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Winnipeg, Queen's Printer, 1963-75.

TABLE 20

Hens and Chickens in Various Crop Districts Over Time (In 000)

Crop District	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	130	130	120	110	105	95	87	65	80	95	79.0	61	48	54
2	345	345	325	360	355	355	315	235	270	260.8	232.0	205	205	176
3	1,320	1,450	1,405	1,485	1,390	1,385	1,497	1,425	1,640	1,409.3	1,297.0	1,278	1,240	1,194
4	230	260	260	210	200	240	238	170	200	167.2	150.0	139	117	115
5	1,505	1,550	1,880	1,695	1,910	2,290	2,391	2,100	2,415	1,650.2	1,518.0	1,497	1,410	1,244
6	240	265	315	330	340	280	307	280	355	299.1	275.0	244	195	200
7	200	185	190	195	190	160	154	120	140	139.1	120.0	94	88	82
8	260	260	310	240	230	315	306	215	260	274.3	244.0	200	192	195
9	250	250	275	210	215	310	273	235	275	215.2	192.0	174	190	170
10	270	240	280	255	235	225	189	125	150	139.9	113.0	76	73	61
11	260	290	310	295	320	230	213	160	185	143.2	118.0	89	78	75
12	195	200	230	185	210	200	205	165	205	226.1	202.0	163	175	150
13	145	150	180	140	125	110	93	75	85	70.9	52.0	45	39	32
14	115	125	130	110	115	135	112	70	80	76.8	68.0	45	45	39

Source; Manitoba Department of Agriculture Manitoba Agriculture Yearbook, Winnipeg, Queen's Printer, 1963-75.

TABLE 21

Food Consumption of Various Commodities in Canada Over Time

Year	Wheat	Oats	Barley	Flaxseed	Rye
	bushels				
1960	56,265,000	5,203,000	196,000	1,000	446,000
1961	58,924,000	5,148,000	193,000	1,000	414,000
1962	53,038,000	5,292,000	188,000	300	431,000
1963	59,079,000	5,714,000	212,000	300	468,000
1964	57,507,000	5,816,000	208,000	1,000	454,000
1965	60,943,000	5,534,000	156,000	800	451,000
1966	59,006,000	5,533,000	145,000	1,000	439,000
1967	60,463,000	5,221,000	133,000	1,000	423,000
1968	61,397,000	4,571,000	164,000	1,000	450,000
1969	64,627,000	4,786,000	108,000	2,000	465,000
1970	64,361,000	4,814,000	126,000	1,000	458,000
1971	65,426,000	4,986,000	119,000	1,000	509,000
1972	64,685,000	5,000,000	116,000	1,000	505,000
1973	66,781,000	3,947,000	149,000	2,000	497,000
1974	69,945,000	4,321,000	141,000		500,000

Source, Statistics Canada, Grain Trade of Canada, Cat. No. 22-201, 1966-75.

TABLE 22

Use of Various Commodities for Industrial Purposes in Canada

Year	Wheat	Barley	Flaxseed	Rapeseed	Rye
			bushels		
1960	1,468,086	14,608,876	2,916,230		1,229,514
1961	1,473,097	14,107,501	2,464,829		1,219,695
1962	1,528,718	15,633,134	2,529,185		1,287,611
1963	1,541,700	14,553,524	2,750,118		1,379,691
1964	1,711,146	16,208,666	2,901,402		1,686,432
1965	1,859,765	16,018,163	2,630,729	3,745,507	1,798,327
1966	1,900,000	17,684,163	2,542,947	4,963,009	1,804,000
1967	2,397,000	16,921,000	2,266,000	5,159,000	2,605,000
1968	1,146,000	17,312,000	2,085,000	6,934,000	2,244,000
1969	461,000	18,400,000	2,490,000	7,768,000	2,844,000
1970	517,000	18,065,000	2,827,000	8,575,000	2,881,000
1971	315,000	20,921,000	3,101,000	12,050,000	2,800,000
1972	500,000	18,706,000	2,633,000	15,572,000	2,795,000
1973	806,000	18,908,000	762,000	14,745,000	3,800,000
1974	800,000	22,048,000		12,168,000	3,200,000

Source, Statistics Canada, Grain Trade of Canada, Cat. No. 22-201, 1966-75.

TABLE 23

Total Production of Various Commodities
In Canada Over Time

ear	Wheat	Oats	Barley	Flaxseed	Rapeseed	Rye
	---------thousand bushels---------					
960	518,379	398,505	193,473	22,571		10,221
961	283,394	283,965	112,640	14,478		6,519
962	565,585	492,610	165,872	16,065		12,251
963	723,500	445,877	221,235	21,116		13,760
964	600,726	347,006	168,463	20,305		12,345
965	649,412	399,983	218,300	29,176	22,600	17,834
966	827,338	370,678	296,235	22,520	25,800	17,220
967	592,948	301,772	252,867	9,378	24,700	11,967
968	649,950	356,700	326,045	19,666	19,400	13,024
969	671,212	354,895	371,288	28,048	33,400	15,155
970	331,579	353,073	408,287	47,966	72,200	18,905
971	529,552	363,479	601,628	22,387	95,000	21,915
972	533,288	300,208	518,316	17,617	57,300	13,524
973	593,738	326,880	469,570	19,400	53,200	14,282
974	488,513	254,745	404,286	13,800	51,300	18,914

ource; Statistics Canada, Grain Trade of Canada, Cat. No. 22-201, 1966-75.

TABLE 24

Export of Various Commodities From Canada Over Time

r	Wheat	Oats	Barley	Flax	Rapeseed	Rye
	---------------------------	---bushels---	---------------------------			
0	353,249,439	2,679,652	47,178,102	13,603,333		2,613,234
1	358,021,822	3,454,261	42,909,063	11,987,594		4,362,748
2	331,367,218	21,700,158	15,376,964	12,565,941		7,309,825
3	594,547,631	18,758,927	46,935,184	13,638,472		5,501,099
4	399,594,316	15,551,136	37,032,119	14,346,118		4,857,951
5	584,905,946	15,921,687	38,028,594	18,935,830	13,632,267	8,050,040
6	515,306,608	4,802,891	58,541,846	16,568,065	13,817,739	9,962,942
7	336,010,000	3,545,000	41,405,000	12,611,000	12,309,000	4,760,000
8	305,838,000	2,723,000	26,407,000	13,421,000	14,311,000	4,248,000
9	346,498,000	5,165,000	88,313,000	18,611,000	22,213,000	3,829,000
0	435,257,000	13,366,000	179,595,000	21,194,000	46,811,000	8,917,000
1	503,764,000	10,454,000	230,558,000	25,741,000	42,603,000	10,757,000
2	576,594,000	6,925,000	165,248,000	19,640,000	54,059,000	8,236,000
3	419,387,000	838,000	127,480,000	15,503,000	39,184,000	4,584,000
4	394,594,000	1,415,000	138,393,000	10,519,000	26,145,000	4,843,000

rce; Statistics Canada, Grain Trade of Canada, Cat. No. 22-201, 1966-75.

TABLE 25

Values of Farm Lands per Acre Including Buildings in Different Crop Districts Over Time

Year	Crop District 1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Dollars per Acre													
1961	31	44	71	52	68	29	29	36	31	31	30	19	37	16
1962	42	56	89	70	66	43	36	56	47	42	42	35	50	30
1963	46	59	90	70	68	41	39	60	49	46	45	35	54	31
1964	53	67	101	76	73	44	49	76	57	57	45	36	68	37
1965	64	74	113	80	83	47	56	83	65	64	53	43	80	37
1966	73	83	124	94	86	52	70	94	74	77	63	48	80	40
1967	91	100	140	108	95	58	76	95	76	85	72	50	87	49
1968	99	110	150	119	104	63	78	99	81	88	82	56	97	52
1969	81	103	135	109	102	63	66	96	73	74	74	60	96	53
1970	73	95	120	88	97	57	58	91	71	71	72	59	81	43
1971	76	89	117	106	110	65	70	88	73	71	71	65	91	52
1972	80	91	112	114	118	60	63	85	80	70	74	62	95	56
1973	84	103	149	132	119	66	71	101	100	78	95	54	88	72
1974	108	126	197	198	185	83	81	120	121	97	110	60	105	83
1975	132	157	244	221	202	98	96	126	138	111	110	63	129	86

Source, Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Queen's Printer, Winnipeg, 1963-75.

TABLE 26

Yield of Different Crops in Manitoba

Year	Wheat	Oats	Barley	Flax	Rye	Rapeseed	Sunflower	Potatoes	Sugarbeet
	---------	---------	---bushels---	---------	---------	---------	lbs.	bu.	tons
1962	26.3	49.6	33.4	11.7	25.2	18.0	750	100	9.12
1963	19.3	38.3	27.4	11.3	22.4	16.9	950	175	12.36
1964	25.1	44.6	32.2	10.3	20.8	17.5	525	200	9.55
1965	24.4	48.5	36.6	12.0	22.5	16.6	550	195	10.12
1966	24.3	41.2	32.0	9.0	23.9	12.4	594	208	10.61
1967	25.6	41.2	34.0	8.6	18.9	15.9	800	182	8.43
1968	26.8	51.3	36.8	12.7	20.8	20.9	650	189	10.26
1969	25.6	45.1	35.0	9.3	18.3	17.9	708	218	11.05
1970	21.8	42.1	34.0	10.9	21.5	18.0	800	187	9.39
1971	29.4	54.5	45.8	10.4	25.5	20.7	750	209	11.76
1972	26.5	48.2	40.5	11.8	22.5	18.1	800	189	11.77
1973	25.8	48.5	39.5	12.7	26.2	19.2	700	244	12.47
1974	21.1	35.8	29.4	9.4	23.9	17.0	867	233	8.23
1975	25.2	45.5	34.0	11.2	24.5	16.9	1065	234	12.42

Source; Manitoba Department of Agriculture, Yearbook of Manitoba Agriculture, Queen's Printer, Winnipeg, 1963-75.

TABLE 27

Average Yield of Wheat, Oats, Barley and Flaxseed In Crop District 1 Over Time

Year	Wheat	Oats	Barley	Flax
	---------------bushels per acre-------------------			
1962	26.2		34.4	11.7
1963	19.1		28.3	10.8
1964	24.5	48.6	32.8	10.5
1965	24.0	47.9	37.1	12.5
1966	23.9	42.0	34.9	9.2
1967	17.1	27.7	23.9	5.5
1968	24.5	49.9	33.9	13.2
1969	28.3	53.0	42.7	10.9
1970	21.4	45.6	34.7	11.0
1971	28.3	50.7	45.0	8.2
1972	25.5	53.6	43.4	12.0
1973	27.4	52.1	44.9	12.4
1974	21.5	33.0	27.8	8.7
1975	24.6	45.4	34.4	10.7

Source; Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Queen's Printer, Winnipeg, 1963-75.

TABLE 28

Average Yield of Wheat, Oats, Barley and Flaxseed in Crop District 2 Over Time

Year	Wheat	Oats	Barley	Flax
	----------------bushels per acre		------------------	
1962	26.5		34.8	12.3
1963	18.5		26.2	12.1
1964	27.2	50.6	31.9	10.8
1965	25.2	49.9	38.1	12.2
1968	25.5	42.0	34.2	9.5
1967	25.0	38.7	31.7	7.5
1968	30.2	60.2	41.7	14.8
1969	26.8	49.0	37.9	11.9
1970	23.3	45.8	37.2	11.9
1971	30.8	59.4	49.0	11.6
1972	27.7	51.4	43.7	13.6
1973	27.7	54.3	43.4	13.8
1974	20.5	35.7	26.0	9.4
1975	25.7	48.0	36.5	11.6

Source; Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Queen's Printer, Winnipeg, 1963-75.

TABLE 29

Average Yield of Wheat, Oats, Barley
and Flaxseed in Crop District 3 Over Time

Year	Wheat	Oats	Barley	Flax
	---bushels per acre---			
1962	24.4		28.3	11.9
1963	14.1		19.9	11.5
1964	23.4	48.6	30.6	9.6
1965	26.8	51.1	38.2	11.5
1966	20.3	39.2	26.8	8.0
1967	27.2	49.6	36.8	9.4
1968	27.3	55.1	35.7	13.5
1969	18.5	38.6	25.9	7.7
1970	19.4	39.1	29.8	8.3
1971	29.0	57.5	46.6	9.9
1972	25.9	48.0	38.6	10.3
1973	25.6	53.7	42.6	12.2
1974	19.9	38.0	28.0	9.1
1975	27.2	52.2	38.1	10.9

Source; Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Queen's Printer, Winnipeg, 1963-75.

TABLE 30

Average Yield of Wheat, Oats, Barley and Flaxseed in Crop District 4 Over Time

Year	Wheat	Oats	Barley	Flax
	---------------------bushels per acre------------------			
1962	24.2		23.9	10.2
1963	11.0		14.8	10.2
1964	26.9	47.1	35.0	11.8
1965	27.6	50.1	36.1	11.3
1966	25.8	43.5	31.5	10.0
1967	29.6	46.1	40.1	11.2
1968	29.1	56.2	38.7	13.1
1969	19.2	32.7	21.2	9.0
1970	20.8	37.3	29.0	10.0
1971	29.8	52.4	44.4	11.4
1972	28.1	47.2	41.0	11.7
1973	26.6	50.0	37.0	12.8
1974	20.7	36.6	26.6	9.6
1975	27.3	45.2	32.7	11.9

Source; Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Queen's Printer, Winnipeg, 1963-75.

TABLE 31

Average Yield of Wheat, Oats, Barley and Flaxseed in Crop District 5 Over Time

Year	Wheat	Oats	Barley	Flax
	----------------bushels per acre----------------			
1962	25.4		26.7	10.2
1963	11.4		16.9	11.3
1964	20.9	38.7	28.4	10.1
1965	25.8	41.8	34.7	10.5
1966	18.6	35.2	21.3	7.9
1967	25.4	29.9	34.3	10.3
1968	26.4	40.7	33.1	12.8
1969	17.2	36.3	24.4	8.1
1970	17.0	33.6	24.5	8.6
1971	27.2	53.4	43.6	11.5
1972	27.5	45.7	39.0	12.0
1973	23.7	46.4	32.3	12.3
1974	17.6	32.8	23.3	8.8
1975	22.6	44.2	29.2	10.4

Source: Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Queen's Printer, Winnipeg, 1963-75.

TABLE 32

Average Yield of Wheat, Oats, Barley and Flaxseed in Crop District 6 Over Time

Year	Wheat	Oats	Barley	Flax
	-----------------bushels per acre-----------------			
1962	21.0		21.2	10.0
1963	11.1		13.3	10.2
1964	20.3	38.7	23.5	10.9
1965	25.5	48.8	36.7	12.2
1966	17.5	25.3	21.4	8.2
1967	25.9	39.9	32.3	11.9
1968	27.2	39.5	37.0	12.3
1969	20.7	37.6	35.0	13.3
1970	18.1	28.8	25.6	12.2
1971	28.1	47.6	43.7	13.0
1972	24.6	42.2	40.2	12.6
1973	25.9	40.2	38.8	12.1
1974	16.9	28.4	22.1	8.9
1975	21.6	38.6	29.6	10.2

Source; Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Queen's Printer, Winnipeg, 1963-75.

TABLE 33

Average Yield of Wheat, Oats, Barley and Flaxseed in Crop District 7 Over Time

Year	Wheat	Oats	Barley	Flax
	-----------------bushels per acre-----------------			
1962	25.8		36.0	11.3
1963	22.5		30.2	11.7
1964	24.2	48.4	33.8	10.7
1965	24.2	51.8	37.4	12.5
1966	23.4	39.8	33.9	9.2
1967	23.4	33.9	29.9	7.3
1968	22.2	45.4	34.7	8.8
1969	28.4	51.1	41.6	12.0
1970	22.5	42.2	35.2	11.8
1971	27.6	49.0	44.8	9.7
1972	24.6	49.6	39.7	11.2
1973	25.7	48.3	43.4	12.8
1974	22.3	39.4	30.5	10.6
1975	25.3	44.6	34.0	12.0

Source; Manitoba Department of Agriculture, Manitoba Department Yearbook, Queen's Printer, Winnipeg, 1963-75.

TABLE 34

Average Yield of Wheat, Oats, Barley and Flaxseed in Crop District 8 Over Time

Year	Wheat	Oats	Barley	Flax
	------------------bushels per acre------------------			
1962	26.8		35.2	11.9
1963	19.5		26.7	10.7
1964	27.6	47.0	35.5	11.9
1965	26.0	47.5	37.3	12.1
1966	25.8	44.7	35.0	9.0
1967	26.7	41.6	34.5	8.7
1968	28.7	59.2	43.5	13.0
1969	27.3	49.4	40.2	12.6
1970	23.2	48.0	37.6	12.8
1971	31.3	60.1	49.0	12.4
1972	28.7	53.3	47.1	13.6
1973	26.4	52.2	46.0	14.6
1974	22.2	39.3	33.5	11.1
1975	27.5	48.2	37.5	13.0

Source, Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Queen's Printer, Winnipeg, 1963-75.

TABLE 35

Average Yield of Wheat, Oats, Barley
and Flaxseed in Crop District 9 Over Time

Year	Wheat	Oats	Barley	Flax
	------------------bushels per acre------------------			
1962	26.9		34.9	11.5
1963	19.8		24.1	10.1
1964	26.0	45.7	31.8	11.5
1965	22.7	46.4	35.7	11.2
1966	23.3	39.2	33.8	8.8
1967	27.0	37.0	33.8	9.0
1968	28.1	54.8	37.1	11.9
1969	24.5	43.1	33.3	10.5
1970	23.0	44.3	34.9	12.1
1971	25.0	46.0	39.0	9.9
1972	26.8	49.3	41.2	11.0
1973	24.0	44.2	34.9	12.9
1974	21.7	35.4	31.3	10.6
1975	23.3	40.1	30.9	11.0

Source; Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Queen's Printer, Winnipeg, 1963-75.

TABLE 36

Average Yield of Wheat, Oats, Barley and Flaxseed in Crop District 10 Over Time

Year	Wheat	Oats	Barley	Flax
	--------------------bushels per acre------------------			
1962	28.2		34.4	12.8
1963	30.1		38.1	13.4
1964	30.0	60.3	36.3	12.5
1965	26.6	54.8	39.2	12.8
1966	28.3	53.6	39.7	12.2
1967	28.5	42.3	37.6	9.4
1968	25.9	50.0	39.5	9.5
1969	32.1	59.1	46.4	14.1
1970	26.3	53.4	42.0	14.4
1971	32.4	57.3	50.0	13.7
1972	26.5	51.3	42.7	12.4
1973	25.7	46.2	41.6	12.7
1974	25.0	42.5	40.6	11.3
1975	25.8	46.8	35.8	11.1

Source; Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Queen's Printer, Winnipeg, 1963-75.

TABLE 37

Average Yield of Wheat, Oats, Barley and Flaxseed in Crop District 11 Over Time

Year	Wheat	Oats	Barley	Flax
	----------------- bushels per acre -----------------			
1962	27.3		34.9	12.1
1963	26.3		28.2	12.9
1964	23.4	38.6	28.6	10.8
1965	28.3	58.5	36.3	12.6
1966	27.4	44.7	33.6	11.1
1967	27.0	45.2	32.3	10.4
1968	23.9	47.9	31.4	11.0
1969	30.6	51.7	37.4	13.9
1970	23.9	44.4	36.3	14.1
1971	29.7	53.8	42.7	11.8
1972	25.1	42.3	34.4	10.8
1973	25.4	41.2	31.9	10.5
1974	19.8	33.4	26.4	9.2
1975	23.8	42.6	30.5	9.5

Source; Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Queen's Printer, Winnipeg, 1963-75.

TABLE 38

Average Yield of Wheat, Oats, Barley and Flaxseed in Crop District 12 Over Time

Year	Wheat	Oats	Barley	Flax
	----------------bushels per acre----------------			
1962	25.7		32.7	11.4
1963	11.0		13.4	8.4
1964	21.6	35.2	28.1	11.3
1965	26.0	48.9	31.1	9.0
1966	26.4	42.4	34.4	12.6
1967	27.0	43.0	35.6	12.6
1968	28.4	46.4	37.1	13.1
1969	26.0	49.4	35.3	12.1
1970	23.0	41.6	33.5	12.5
1971	32.6	55.9	47.7	14.8
1972	28.7	46.8	38.8	14.3
1973	27.1	54.2	33.8	13.3
1974	16.0	27.8	21.4	8.3
1975	19.6	32.1	23.0	10.3

Source; Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Queen's Printer, Winnipeg, 1963-75.

TABLE 39

Average Yield of Wheat, Oats, Barley and Flaxseed in Crop District 13 Over Time

Year	Wheat	Oats	Barley	Flax
	-----------------	bushels per acre	-------------------	
1962	30.8		37.4	13.5
1963	29.4		31.8	14.2
1964	28.5	45.7	31.6	12.0
1965	27.6	48.8	34.1	10.7
1966	32.6	52.1	36.1	12.5
1967	30.6	46.6	35.1	13.3
1968	29.5	55.8	36.3	12.5
1969	32.9	53.3	39.6	14.3
1970	28.4	46.0	35.5	15.8
1971	32.5	61.6	44.5	15.6
1972	28.5	37.6	37.5	12.9
1973	26.3	45.2	29.2	15.3
1974	25.7	36.6	29.6	14.5
1975	28.3	45.7	30.6	16.2

Source, Manitoba Department of Agriculture, Manitoba Agriculture Yearbook, Queen's Printer, Winnipeg, 1963-75.

TABLE 40

Average Yield of Wheat, Oats, Barley and Flaxseed in Crop District 14 Over Time

Year	Wheat	Oats	Barley	Flax
	---------------bushels per acre---------------------			
1962	26.5		34.1	10.7
1963	17.2		21.5	9.1
1964	18.2	28.7	25.5	8.5
1965	21.5	34.1	29.7	11.2
1966	21.5	38.0	30.7	8.8
1967	22.1	35.8	27.6	8.4
1968	28.4	49.5	35.3	11.6
1969	25.7	41.0	33.0	9.3
1970	21.6	40.1	29.3	10.2
1971	24.0	42.3	36.0	9.7
1972	25.7	42.9	33.6	9.4
1973	25.1	40.1	38.8	11.2
1974	20.9	30.7	28.0	9.1
1975	21.8	36.1	26.5	10.3

Source; Manitoba Department of Agriculture, Manitoba Agriculture, Manitoba Agriculture Yearbook, Queen's Printer, Winnipeg, 1963-75.

TABLE 41

Income Data for Sunflowers[1]

	Crop District													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	- - - - - - - - - - - - dollars - - - - - - - - - - - -													
Gross Income Per Acre ($.095/lb)	102.08	107.15	102.92	108.42	93.32	--	100.71	96.90	--	--	96.64	--	112.36	--
Less Seed $1.58/Ac.	1.58	1.58	1.58	1.58	1.58	--	1.58	1.58	--	--	1.58	--	1.58	--
Total Cost	57.67	59.15	63.37	61.62	62.55	--	56.49	58.14	--	--	57.01	--	57.98	--
Net Return Per Acre	42.83	46.42	37.97	45.22	29.19	--	42.64	37.18	--	--	38.05	--	52.80	--

[1]Gross income per acre was determined by multiplying the yield per acre given in Table 32 (b) by the price per pound of sunflower. Seed cost reported by Framingham, Craddock and Baker op. cit. was adjusted by using the farm input price index. Total cost was obtained by using the procedure discussed in Chapter IV. No transportation cost was considered as we used the farm price.

TABLE 42

Income Data for Potatoes[1]

	Crop District													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Dollars													
Gross Income Per Acre (@ 2.33/bu.)	-	694.52	667.10	702.75	--	--	652.77	712.34	628.07	683.76	626.40	658.25	--	--
Seed @ $41.07 per acre	-	41.07	41.07	41.07	--	--	41.07	41.07	41.07	41.07	41.07	41.07	--	--
Total Cost	-	221.39	225.61	223.86	--	--	218.73	220.38	220.15	219.22	219.25	216.42	--	--
Net Income Per Acre	-	432.06	400.42	437.82	--	--	392.97	450.89	366.85	423.47	366.08	400.76	--	--

[1]Gross income per acre was determined by multiplying the yield per acre given in Table 32 (b) by the price per bushel. Seed cost reported by Framingham, Craddock and Baker op. cit. was ad-sting by using the farm input index. Storage cost included in the total cost was also adjusted by using the farm input index. Total cost was obtained by using the procedure discussed in Chapter IV. No transportation cost was deducted as we used the farm price.

TABLE 43

Income Data for Sugarbeets[1]

	Crop District													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	--------Dollars--------													
Gross Income per Acre ($35/ton)	-	527.45	506.80	533.75	--	--	--	--	477.05	519.40	475.65	--	--	-
Less seed $5.25/acre	-	5.25	5.25	5.25	--	--	--	--	5.25	5.25	5.25	--	--	-
Total Cost	-	280.29	284.52	282.76	--	--	--	--	279.05	278.12	278.15	--	--	-
Net Income per Acre	-	241.91	217.03	245.74	--	--	--	--	192.75	236.03	192.25	--	--	-

[1]Gross income per acre was determined by multiplying the yield per acre given in Table 32 (b) by the price per ton of sugarbeet. Seed cost reported by Framingham, Craddock and Baker op. cit., was adjusted by using the farm input price index. Total cost was obtained by using the procedure discussed in Chapter IV. No transportation cost was considered as we used the farm price.

TABLE 44

Net Income per Acre from Various Crops on Different Soil Types Based on 1971 Prices[1]

Crop Dist.	Soil Type	Wheat	Oats	Barley	Flaxseed	Rapeseed	Rye	Sunflower	Potatoes	Sugar-beets
		----------	----------	----------	----------	Dollars per acre	----------	----------	----------	----------
1	1	-7.04	-16.72	-14.24	-17.80	-14.48	-32.00	5.87	--	--
	2	-5.60	-15.09	-12.54	-15.34	-11.53	-30.48	5.87	--	--
2	1	-5.66	-15.51	-13.59	-13.33	-12.67	-31.55	7.59	70.26	4.11
	2	-4.30	-13.89	-11.92	-10.85	-9.74	-30.05	7.59	70.26	4.11
3	1	-13.04	-21.60	-20.11	-26.01	-21.06	-38.23	0.70	53.57	-11.37
	2	-11.01	-19.54	-18.04	-21.80	-16.81	-36.19	0.70	53.57	-11.37
4	1	-9.42	-23.00	-20.14	-18.75	-16.65	-35.02	5.93	71.54	5.08
	2	-7.41	-20.94	-18.16	-14.52	-12.41	-32.99	5.93	71.54	5.08
5	1	-16.83	-23.51	-25.55	-23.30	-24.73	-39.00	-4.54	--	--
	2	-14.81	-21.45	-23.52	-19.10	-20.48	-36.96	-4.54	--	--
6	1	-10.58	-23.69	-16.97	-12.94	-17.60	-33.61	--	--	--
	2	-8.09	-20.95	-14.35	-11.24	-14.50	-31.12	--	--	--
7	1	-6.22	-16.34	-13.66	-13.66	-13.82	-31.01	6.19	53.93	--
	2	-4.83	-14.74	-12.00	-10.92	-10.84	-28.61	6.19	53.93	--
8	1	-3.33	-13.16	-9.43	-9.30	-10.60	-29.97	2.13	79.33	--
	2	-1.97	-11.57	-7.78	-6.85	-7.71	-28.53	2.13	79.33	--
9	1	-9.47	-19.87	-17.18	-15.51	-16.72	-32.67	--	41.27	-22.81
	2	-8.11	-18.25	-15.57	-13.04	-13.76	-31.20	--	41.27	-22.81
10	1	-5.81	-18.20	-11.43	-13.28	-13.44	-31.60	--	67.54	1.90
	2	-4.38	-16.61	-9.76	-10.79	-10.44	-30.10	--	67.54	1.90
11	1	-9.94	-21.85	-20.82	-18.63	-18.04	-33.03	3.10	41.41	-21.98
	2	-8.74	-19.20	-18.10	-14.68	-12.19	-30.81	3.10	41.41	-21.98
12	1	-7.65	-19.75	-19.99	-9.66	-14.37	-32.07	--	58.73	--
	2	-5.16	-16.92	-17.35	-6.83	-10.22	-29.61	--	58.73	--
13	1	-4.07	-20.37	-21.52	-4.59	-11.26	-31.31	12.05	--	--
	2	-2.01	-17.34	-19.28	-1.05	-5.45	-29.28	12.05	--	--
14	1	-9.86	-20.38	-19.76	-18.62	-16.09	-33.40	--	--	--
	2	-7.41	-17.61	-17.13	-15.46	-11.67	-30.96	--	--	--

[1]Procedure used for determining the net income is discussed in Chapter IV.

TABLE 45

Optimal Acreage Allocated to Different Crops in Various Regions and in Manitoba in Solution Two [1]

Crop	Interlake	Eastern	Central	South West	North West	Total
	Acres					
Wheat	163,771	120,839	1,059,838	1,151,815	590,270	3,086,530
Oats	54,663	77,182	227,405	266,900	132,560	758,711
Barley	14,719	36,497	562,308	677,826	131,430	1,422,778
Flaxseed	18,418	23,401	135,288	105,445	23,437	305,990
Rapeseed	30,013	31,616	105,261	146,417	55,974	369,280
Rye	1,936	4,385	16,828	18,602	10,860	52,611
Sunflower	5,941	1,176	53,169	65,720	3,602	129,607
Potatoes	1,737	--	11,797	13,040	1,059	27,633
Sugarbeets	2,998	--	14,670	6,236	336	24,240
Total	294,195	295,094	2,186,563	2,451,999	949,529	6,177,378

[1] Based on the model.

TABLE 46

Distribution of Optimal Production Among Regions in Solution Two[1]

Crop	Interlake	Eastern	Central	South West	North West	Total
	Bushels					
Wheat	5,009,166	3,316,831	32,307,364	34,865,265	17,498,344	92,996,972
Oats	3,022,262	4,337,735	14,283,427	16,248,145	7,157,417	45,048,987
Barley	654,384	1,601,616	28,346,229	34,436,075	6,161,161	71,199,466
Flaxseed	286,160	324,840	1,833,941	1,517,999	329,058	4,291,997
Rapeseed	696,341	666,635	2,473,785	3,404,102	1,313,401	8,554,264
Rye	55,309	112,614	486,069	532,830	316,274	1,503,097
Sunflower	6,766,975*	1,155,023*	58,584,124*	70,436,837*	4,086,998*	141,029,962*
Potatoes	522,000	--	3,535,359	3,818,428	290,210	8,165,996
Sugarbeets	45,722**	--	219,877**	93,606**	4,789**	363,993**

[1]Based on the model.

* in pounds

** in tons

TABLE 47

Optimum Acreage Allocated to Different Crops in Various Crop Districts Under Solution One [1]

Crop District	Wheat	Oats	Barley	Flaxseed	Rapeseed	Rye	Sunflower	Potatoes	Sugarbeets
	----------	----------	----------	----------	Acres	----------	----------	----------	----------
1	296,585	98,024	151,439	151,234	54,300	13,244	8,431	--	--
2	357,811	151,848	249,636	91,672	65,659	15,982	54,863	11,067	18,246
3	607,833	280,729	383,652	396,016	111,320	27,147	3,269	248	3,634
4	75,393	74,095	92,465	20,563	13,838	3,368	5,860	1,641	2,998
5	306,917	181,713	201,930	85,164	55,968	4,288	1,256	--	--
6	30,889	36,855	16,603	10,313	56,449	1,378	--	--	--
7	214,975	106,315	148,590	59,388	39,343	9,353	28,377	4,729	--
8	218,283	131,387	140,572	55,409	40,099	9,753	23,949	7,508	--
9	215,134	141,261	95,602	56,685	39,301	9,601	--	601	570
10	382,633	128,818	226,441	75,543	70,165	17,091	--	958	777
11	280,851	132,934	180,184	67,515	51,304	12,536	1,045	785	265
12	82,228	59,441	78,290	31,037	15,054	3,672	--	96	--
13	123,070	55,942	121,770	5,742	22,622	5,500	2,557	--	--
14	104,750	32,317	60,536	37,452	19,142	1,121	--	--	--

[1] Based on the model.

TABLE 48

Percent Decrease of Optimal Acreage in Solution Two as Compared to Solution One for Various Crops by Region[1]

Crop	Interlake	Eastern	Central	South West	North West	Manitoba
Wheat	7.61	62.02	--	--	--	6.39
Oats	62.34	62.70	54.94	46.54	48.13	52.92
Barley	91.99	82.25	16.36	--	67.81	33.75
Flaxseed	66.55	74.01	73.72	70.54	81.09	73.24
Rapeseed	7.57	70.95	45.80	30.61	48.19	43.58
Rye	73.53	18.68	63.78	63.66	54.13	60.74
Sunflower	--	--	--	--	--	--
Potatoes	--	--	--	--	--	--
Sugarbeets	--	--	11.59	2.61	68.27	8.49
Total	52.06	68.48	28.86	19.19	37.32	32.65

[1]Calculated from Table 49 and Appendix C Table 18.

TABLE 49

Optimum Acreage Allocated to Different Crops by Crop District in Solution Two[1]

Crop District	Wheat	Oats	Barley	Flaxseed	Rapeseed	Rye	Sunflower	Potatoes	Sugarbeets
	Acres								
1	296,585	39,157	151,440	52,655	17,941	4,376	8,431	--	--
2	357,811	57,454	249,636	31,710	65,659	5,658	54,863	11,067	18,246
3	607,833	101,035	287,427	99,141	35,097	8,559	3,269	248	1,804
4	75,393	30,077	7,943	8,171	13,838	934	5,860	1,641	2,998
5	96,100	75,443	21,255	22,909	17,524	4,288	1,256	--	--
6	30,889	6,567	16,602	1,958	15,213	371	--	--	--
7	214,975	65,523	148,590	16,939	27,175	3,664	28,377	4,729	--
8	218,283	131,387	140,572	13,452	40,099	6,456	23,949	7,508	--
9	215,134	45,870	95,602	14,870	11,595	2,833	--	601	282
10	382,633	65,011	226,441	13,921	70,165	5,020	--	958	777
11	280,851	69,194	28,692	9,656	12,709	3,105	1,045	785	132
12	82,228	19,758	5,416	8,780	15,054	727	--	96	--
13	123,070	19,919	38,639	1,314	22,622	5,500	2,557	--	--
14	104,750	32,317	4,527	10,514	4,591	1,121	--	--	--

[1]Based on the model.

TABLE 50

Percentage Contribution of Optimal Crop
Acreage Among Various Regions in Solution Two[1]

Crop	Interlake	Eastern	Central	South West	North West	Province
			Percent			
Wheat	5.31	3.91	34.34	37.32	19.12	100.00
Oats	7.20	10.18	29.97	35.18	17.47	100.00
Barley	1.03	2.57	39.52	47.64	9.24	100.00
Flaxseed	6.02	7.65	44.21	34.46	7.66	100.00
Rapeseed	8.13	8.56	28.50	39.65	15.16	100.00
Rye	3.68	8.33	31.99	35.36	20.64	100.00
Sunflower	4.58	0.91	41.02	50.71	2.78	100.00
Potatoes	6.29	0.00	42.69	47.19	3.83	100.00
Sugarbeets	12.36	0.00	60.52	25.73	1.39	100.00
Total	4.76	4.78	35.40	39.69	15.37	100.00

[1]Based on the model.

TABLE 51

Value of Optimal Crop Production
For Various Regions and for Manitoba
in Solution Two[1]

Crop	Interlake	Eastern	Central	South West	North West	Total
	---	---	---	dollars	---	---
Wheat	7,212,470	4,793,347	46,522,544	50,263,056	25,040,704	133,915,600
Oats	1,692,296	2,451,513	7,998,716	9,045,517	3,965,701	25,227,424
Barley	471,109	1,161,427	20,409,264	24,711,552	4,383,461	51,263,616
Flaxseed	595,152	677,343	3,814,593	3,155,611	680,346	8,927,354
Rapeseed	1,385,579	1,330,043	4,922,828	6,768,346	2,597,401	17,022,976
Rye	33,493	68,694	291,642	318,065	187,881	901,858
Sunflower	405,978	69,301	3,515,046	4,249,875	245,073	8,461,797
Potatoes	553,264	--	3,747,478	4,070,199	307,438	8,655,959
Sugarbeets	872,286	--	4,195,243	1,796,003	91,316	6,944,994
	13,221,630	10,551,671	95,417,386	104,378,239	37,499,327	260,352,882

[1]Based on the model.