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WHEAT ACREAGE RESPONSE TO DELIVERY QUOTAS

by

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ABSTRACT

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by George Andrusiak

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Producer delivery quotas were implemented by the Canadian Wheat Board in order to regulate the flow of grain into country elevators, but since 1952 there have been, in most years, restrictions imposed on total grain marketings by the quota system. The effects of these restrictions on producers' supply response had been neglected by researchers and only in recent years has this aspect received investigation. Though recognized as desirable for production efficiency, productivity features have not yet been incorporated into the quota system. This has been due in part to the lack of knowledge of whether variations in responses to quotas exist on a productivity basis due to the restrictiveness imposed by the quota system.

A model approximating wheat acreage seeding decisions was conceptualized, wherein five groups of factors (price of wheat, returns from other crops, wheat exports, farm wheat stocks, and quotas) were hypothesized to influence wheat acreage. Specific factors were singled out from within each of these groups and specified in terms of lagged effects on wheat acreage. These specific factors were tested through regression techniques to discover their individual roles in influencing acreage seeded to wheat. Special consideration was given to the effects of various individual quotas.

The analysis was divided into three sections:

1. An aggregate time series analysis of wheat acreage response in the Prairie Provinces during the 1958 to 1969 period.

2. A regional time series analysis (1961-1969) using delivery point data in order to discover if there were variations in quota response in regions differing in productivity.

3. A combined analysis of aggregate time series and individual producer cross-section data in order to provide extraneous estimation of farm wheat stocks regression coefficients for further improvement of the aggregate analysis.

The results obtained in the aggregate analysis indicated that the prices of barley, oats and flaxseed did not appear to influence wheat acreage. In addition supplementary and unit quotas had no effects. However the price of wheat, farm wheat stocks, wheat export levels, and specified acreage quotas did have significant influences on wheat acreage. Results of the regional analysis showed that there were variations in response to quotas on a productivity basis.

The time-series and cross-section combination provided some verification of aggregate results but failed to improve the final specification due to the recurrence of multicollinearity.

In general, the results indicate that there were responses in wheat acreage to quota experience and that responses differ according to productivity of regions. These findings imply that future agricultural policy should concern itself with the aspects of restrictiveness of quotas and the productivity of regions for attainment of production and marketing efficiency within the Western grains industry.

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CHAPTER I

INTRODUCTION

THE PROBLEM

The Western Canadian grains industry is an important facet of the agricultural composition of Canada. Exports of grain have been historically, and still remain, economically important in terms of balance of payments and employment and income-generation effects. Due to this industry's economic significance every attempt should be made to insure that it operates in the most efficient manner possible. To accomplish this policy makers must have adequate knowledge of the operation of all components of the industry and the economic interaction between these components. One such component of the industry for which such adequate understanding is lacking is that of producer delivery quotas.

Since 1939 the Western grains industry has not operated in an open market context but has been regulated[1] to a large extent by the Canadian Wheat Board; a federally commissioned body. The Wheat Board acts as a sole purchaser of wheat from producers and as a marketing agency on behalf of the producers for wheat, oats and barley. As a marketing agency it sells in both the captive domestic and oligopolistic international grain trade. Besides performing these marketing functions the Wheat Board

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[1]The industry has been 'regulated' since 1939 as this was the first year in which marketing limitations were established by the Canadian Wheat Board.

controls the movement of the other three major crops (rye, flaxseed and rapeseed) through the country elevator-railway line marketing system. The regulation of the farm to country elevator flow of grain is accomplished by the Canadian Wheat Board through the implementation of producer delivery quotas.

> By means of the delivery quota system the Board can regulate where, when, what and how much grain producers in the designated areas of Western Canada can deliver into country elevators.[1]

Though restrictions on producer deliveries of grain were first imposed by means of delivery quotas during the 1939-40 crop-year, and limited delivery opportunities followed for several years, there were no instances of marketing restrictions by crop-year end during the 1944 to 1952 period. However, beginning in 1952, quotas became restrictive as well as regulatory. This meant that there was a limit imposed on the total amount of grain which could be delivered to country elevators by each producer during each crop-year. Wheat deliveries have been the most restricted, since wheat delivery quotas have been declared 'open' (i.e. no limits were set on producer deliveries) on only three occasions since the 1953-54 crop-year.

Surprisingly this restrictive aspect of quotas has received little attention by students of the Western grains industry as well as agricultural policy formulators. The supply control feature of other

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[1]The Boden Committee. Report on Delivery Quota System For Western Canadian Grain. Ottawa: February, 1970. p. 1.

agricultural marketing board quotas is a recognized fact by agricultural theoreticians. Why the restrictive aspects of Canadian Wheat Board quotas, which are in such proximity to farmers, should be completely neglected in research until recent years is not known. Perhaps because orderly marketing of Western Canadian grain and equal delivery opportunities for producers have been the focal points of quota policy the possible effects of quotas on production decisions have been ignored. In a marketing system that not only regulates the rate of producer deliveries during each crop-year, but limits the opportunity for farmers to dispose of their entire crop, there exists the potential for significantly influencing the patterns of production. Because quotas are equitable, these patterns of production may not be efficient--too much wheat may be produced in areas not suited to wheat production and not enough in areas best suited to wheat production.

Only recently have some studies started to examine the possibility of production response to the restrictiveness of Canadian Wheat Board delivery quotas. George G. Pearson in a 1971 study of quota policy states:

> While supply control was never an officially declared objective of quota policy it appears to have been a residual effect in practice.[1]

However treatment of this feature of quota policy, in terms of possible influences on Western Canadian cropping patterns, has been very

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[1]George G. Pearson, "Analysis of Quota Policy: Problems, Objectives and Alternatives in the Western Grain Industry". (Unpublished Masters' thesis, University of Alberta, 1971) p. 38.

minor. This lack of knowledge of historic quota effects may impede the proper use of future quota policy. Since quotas are acknowledged to be a useful marketing tool and their long presence suggests that they have become a permanent feature in the Western grains industry, an immediate expansion of the scant knowledge of prairie grain producers' responses to quotas is required.

A major criticism of the quota system has been that, since it has been utilized to equalize delivery rates among producers, it has failed to recognize the variability in production efficiency among farmers and regions. Therefore it tends to discourage optimal use of factors of production. However, owing to difficulties of definition and measurement, recognized in the Boden Report, productivity has not yet been incorporated into the quota system:

> This (productivity) seems intuitively to be a reasonable concept of equity and efficiency which should be incorporated into a delivery quota system. In practice, productivity is difficult to define and measure objectively. Trying to reflect productivity directly in the quota system does not appear practical at this time.[1]

The fact that the issue of productivity is a difficult one to approach analytically does not detract from the need to learn more about the difference in responses of farmers to quota experience in different areas.

The use of quota policy has as its major goal the coordination of Canadian crops supplies to international demand conditions. In striving

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[1]The Boden Committee, op. cit., p. 16.

for this goal two objectives must be accomplished simultaneously; the prevention of overproduction of certain crops, and the maintenance of supplies of other crops in order to meet previous sales commitments. With a more complete knowledge of farmers' supply response, particularly the response to quota levels, policy makers may be better able to achieve these objectives.

OBJECTIVES OF THE STUDY

In direct relationship to the basic problem that little is known about the influences of quota levels on production decisions in a marketing system which impose restrictions on sales opportunities, this study has the following as its primary objectives:

1. To provide a check on the variables included in previous wheat acreage response studies and make advances in the general area of supply response analysis.

2. To discover what role can be attributed to quota levels in wheat acreage seeding decisions.

3. To analyze various quotas which have been in effect (unit, specified, supplementary) with the purpose of discovering which (if any) have had significant effects on wheat acreage in the past.

4. To discover if there have been variations in responses to quotas by farmers facing different conditions relating to productivity.

The study will primarily be a supply response study even though some factors which influence the actual supply of wheat (in terms of physical volumes) such as weather conditions, fertilizer application, etc. will not be considered. The following distinction is sometimes made:

seeded acreage reflects (at least to some extent) the willingness of producers to respond to variations in prices and other factors influencing income, while the actual production or 'supply' reflects yields as well. Since yields are vulnerable to a wide range of stochastic factors wheat acreage is a better measure of farmers' supply response than is actual production. Therefore this study will abstract from yield and will focus on acreage as the measure for producers' response to quotas.

The study will be restricted to a study of wheat acreage variations for several reasons:

1. Under the historical specified acreage quota system deliveries of wheat were most restrictive since wheat had to be marketed commercially through the Canadian Wheat Board.

2. Wheat is the most important crop grown in Western Canada.

3. Consideration of quota effects on other crops would probably be best accomplished in a sophisticated simultaneous system. Implementation of such a system is necessarily deferred until preliminary analysis show whether such consideration is justified.

PROCEDURES OF ANALYSIS AND PRESENTATION

The first step in the analysis will be the development of a conceptual model which approximates the context in which wheat acreage decisions have to be made. This model will include quotas as an integral component of supply response. Modifications will be made in the basis model to facilitate various stages of aggregate and disaggregate analysis. The analyses to be attempted are:

1. Responses for all of Western Canada as an aggregative unit.

2. Responses in various commercial farming regions of Western Canada. This section will attempt to ascertain the basis for further analysis of the productivity issue in quota allocation.

3. Responses for various farm characteristics such as type of farm and farm size.

The findings in the first stage of the analysis will greatly influence the manner in which the latter two stages are conducted.

Chapter Two provides a background for the analysis. This includes an examination of the features of various quotas which have been in effect, the general operation of the quota system, the workings of the quota system as it now exists, as well as a review of previous studies conducted in this area.

Chapter Three starts with the conceptual framework on which the study is based. Following this the statistical models are developed for empirical work. Finally the data requirements, availability and associated problems are discussed, as well as estimation difficulties and methods of overcoming these.

Chapter Four presents the results of the empirical work.

Chapter Five summarizes the study, deals with policy implications and presents suggestions for continued research in the area of quota policy.

CHAPTER II

BACKGROUND FOR ANALYSIS

The first section of this Chapter provides a brief description of the various grain delivery quotas which have been in effect and some of the more recent developments in quota policy. The quota system was initiated with the intention of providing a mechanism for the regulation of grain deliveries to country elevators. With a few minor exceptions, regulation and not restriction was in fact the result of quota policies up to 1952. Since the restrictive aspect of quotas is of prime concern in this study, changes in quota policy prior to 1952 are not presented here and the interested reader may consult other works such as Pearson,[1] Wood,[2] or the Canadian Wheat Board annual reports.

The latter part of the Chapter reviews past studies of supply response in Western Canadian grain production which have (or should have) considered quotas as a factor.

OUTLINE OF QUOTA POLICY

Historic Quotas

The period from 1954 to 1970 was reasonably stable in the type of quotas which were in effect with the majority of grain deliveries being

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[1] Pearson, op. cit., pp. 32-40.

[2] A. W. Wood, "Regulation of Grain Deliveries in Western Canada: A Historical Summary of the Quota System". (University of Manitoba: Department of Agricultural Economics, 1969). (Mimeographed).

made under the unit, specified acreage and supplementary quotas. A description of these various systems in relation to their imposition of restrictions on deliveries of grain is presented here.

Unit Quota. The unit quota become effective on August 1st, that is, at the beginning of each new crop year. This system was originally implemented to provide the smaller producers with a delivery advantage.

A unit was initially defined as three bushels of wheat, five bushels of barley or rye or eight bushels of oats, though the definition of a unit changed several times in response to relative variations in the prices of the crops involved. Each delivery permit book holder was allowed to deliver grain in any combination not exceeding 100 units. Therefore the unit quota was non-specific as to the type of grain delivered.

Specified acreage quota. The specified acreage quota was used as a basis for deliveries of wheat, oats, barley and rye. Specified acreage originally consisted of acreage seeded to these crops plus land kept in summerfallow, with a later addition of land seeded to eligible grasses and forage crops. This quota was also non-specific as to type of grain delivered. Higher valued grains were generally delivered first by producers in order to increase immediate cash receipts.[1] As a result, wheat (being a high-value crop) was most restricted when specified acreage

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[1]Task Force Report on Agriculture, "Canadian Agriculture in the Seventies." (Ottawa: Queen's Printer, 1969), p. 76.

quotas were not 'opened' at the end of a crop year since wheat had to be commercially marketed through the Canadian Wheat Board. This is in contrast to other crops such as oats and barley which could be marketed without quota regulation:

> The grain producer has several ways in which he can dispose of his oats and barley. During the crop year 1967-68, for example, only 11.8 percent of the total farm supplies of oats and 29.8 percent of the farm supply of barley in the Prairie Provinces were delivered to the Wheat Board. The remainder is disposed of in various ways. A large proportion of the coarse grains is fed directly on the farm. Since 1960 individual grain producers have been permitted to deliver non-quota grain to feed mills which have been designated as non-quota mills by the Canadian Wheat Board. A considerable quantity of feed grains is sold by one farmer to another and to feedlot operators within the same province on a non-quota basis.[1]

A one bushel per specified acre quota level indicated that a farmer could deliver one bushel times his calculated specified acreage of either wheat, oats, barley, or rye. In many cases the non-specific character of this quota created the problem of the wrong grain being delivered (that which was not required for export purposes).

Supplementary quotas. Quotas of this type were used for various grains in order to meet particular circumstances such as a certain grain urgently required for export purposes. Being specific as to type of grain delivered these quotas were used to overcome problems which were forthcoming due to the non-specific character of unit and specified acreage quotas. Supplementary quotas were generally based on acreages seeded to a specific crop.

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[1]Task Force Report on Agriculture, p. 70.

In addition to these three major categories, several other special quotas were used from time to time such as the advance quota for the delivery of damp grains. For the deliveries of flax and rapeseed, seeded acreage quotas were generally used, and were usually non-restrictive.

The Boden Report on Quotas

In January 1970, the Boden Committee was appointed to study the quota system and make recommendations in order to build some flexibility into the system to better gear market supply to market demand conditions. For the first time in a publicly published report, specific objectives of the quota system were clearly outlined along with principles to be adhered to in striving for the objectives. Though many of these had been implicit in the operation methods of the Canadian Wheat Board the delineation of these factors in a formal manner provided a solid basis for changes which were later forthcoming as a result of the report. The report suggested that quotas which were not specific as to the type of grain delivered be dropped, and a new quota system be established which would call for the delivery of specific grains (or grades).

The New 'Assigned Acreage' System

Grain inventories had continued to increase yearly since 1961 and were expected to peak at one billion bushels by July 1970. In order to deplete the stockpiles (which later did surpass the billion bushel mark) the Federal Government initiated the Lower Inventory for Tomorrow program. The LIFT program, as it came to be known paid producers $6.00 to $10.00 per acre for land taken out of production. As a result of the Boden Report and LIFT, major changes were instituted in the quota system.

- Unit and specified acreage quotas were discontinued.

- Only land qualifying as a producer's 'assignable acreage' could be used as a basis for wheat deliveries.

- 'Assignable acreage' was calculated according to a five part formula:[1]

1. The producer's 1970 summerfallow.

2. One-quarter of his 1969 summerfallow.

3. One-quarter of newly broken land.

4. All land seeded to crops other than cereals, oilseeds and forages.

5. Any increase over the previous year in land seeded to perennial forage.

When the producer completed his application for a Wheat Board permit book he had to indicate what portion of his 'assignable acreage' he wished to allocate to wheat deliveries. For other grains quotas were determined by the number of acres seeded to that crop plus any 'assignable acreage' authorized for each of the six quota regulated grains under this selective quota system.

The following crop year (1971-72) the LIFT program was dropped but the new quota system stayed in effect with some modifications.

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[1]The use of the formula used to calculate 'assignable acreage' in order to restrict acreage seeded in the 1970-71 crop-year bears a striking resemblance to the use of 'authorized acreage' during World War II. 'Authorized acreage'--the basis for wheat deliveries--was deemed 65% of the previous year's wheat acreage.

Quotas for all six regulated grains were based on the acreages 'assigned' by producers to the delivery of specific grains.

A new formula was used for calculating a producer's 'assignable acreage':

1. All land seeded to the quota regulated grains (wheat, oats, barley, rye, flaxseed, rapeseed).

2. All summerfallowed land.

3. All land seeded to miscellaneous crops.

4. Land seeded to perennial forage up to a maximum of one-third of the total of the first three categories.

Grain producers were given almost complete freedom in assigning acreages to various crops for delivery purposes when applying for Canadian Wheat Board permits. In addition, producers were allowed to change their assignments <u>once</u> prior to October 31, 1971.

Another new aspect of the quota system was 'non-cumulative' advancement of quota levels for wheat, oats and barley. Under this arrangement the producers were encouraged to deliver the type and grade of grain required for export, by a specified deadline.

In the 1972-73 crop-year most quota aspects remained the same with only minor changes in regard to specialty crops.

This brief resume of quota policy establishes the framework upon which the discussion and empirical analysis of quota effects on wheat acreage can be undertaken.

REVIEW OF PREVIOUS STUDIES

There have been five recent studies which included (or perhaps should have included) Canadian Wheat Board quotas as an institutional factor affecting supply response. These include works by Capel,[1] Schmitz,[2] Pearson,[3] Anim-Appiah[4] and Sahi.[5]

Capel's and Schmitz's studies were carried out in 1968 in an attempt to predict the 1968 wheat acreage. Pearson's work was done in 1971--the most complete analysis of quota policy, to date. Anim-Appiah's and Sahi's were completed in 1972--one a regression type analysis on aggregate versus disaggregate data (not including quotas) and the latter a recursive programming model including quotas as a constraint.

The remainder of this Chapter reviews the methodologies and results of these studies as they pertain to wheat acreage response and quota levels.

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[1]R. E. Capel, "Predicting Wheat Acreage in the Prairie Provinces", Canadian Journal of Agricultural Economics, Vol. 16, No. 2 (June 1968), pp. 87-89.

[2]Andrew Schmitz, "Canadian Wheat Acreage Response," Canadian Journal of Agricultural Economics, Vol. 16, No. 2, 1968. (pp. 79-86).

[3]Pearson, op. cit.

[4]John Anim-Appiah, "Aggregate Versus Disaggregate Acreage Supply Response Models for Prairie Wheat and Barley." Unpublished Doctor's thesis, University of Manitoba, 1972.

[5]Ram Sahi, "Recursive Programming Analysis of Prairie Land Utilization Patterns." Unpublished Doctor's thesis, University of Manitoba, 1972.

Capel

Even as early as 1968, the possible effect of a restrictive quota system on supply response had been recognized. Evidence to this nature was forthcoming in Capel's wheat acreage predictions of 1968 where he included a variable "to account for farmer's expectations on the restrictiveness of quotas"[1] in one of his predicting models. Though both his regression models were excellent in predicting wheat acreage for 1968 the quota-variable specification did provide a slightly better forecast.

Schmitz

The analysis conducted by Schmitz did not account for the restrictiveness of quotas other than in the form of using farm wheat stocks as a variable. Schmitz based his models on the hypothesis that expected wheat prices were the major causes of variations in wheat acreage. Two basic models were specified; traditional and distributed lag.

The distributed lag specification incorporated a lagged endogenous variable--wheat acreage lagged one year. Schmitz admitted that ordinary least squares estimation was probably inappropriate for this form[2] (due to the possibility of auto-correlation in the time series data) but

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[1] Capel, op. cit., p. 88.

[2] Schmitz, op. cit., p. 80.

proceeded to use this method for simplicity.[1]

Variables found to be significant in the traditional model were:

1. The price of wheat - latest price (including final payment) prior to seeding.

2. Flax price - average for the month of April.

3. Time trend.

4. Farm wheat stocks - as of July 31.

A high level of explanatory power (R^2 = .855) and no auto-correlation were attributes of this specification.

The significance of flax prices in explaining wheat acreage is questionable. Flax acreage was only 14% (average value) of the wheat acreage for the time period considered (1947-1966). If the price of any competing crop influenced wheat acreage it should have been the price of barley since barley is the second largest crop in Western Canada. Flax prices should be significant factors only in years of wet spring moisture conditions which would not allow wheat to be seeded.[2]

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[1]Auto-correlated disturbances, alone, do not lead to biased estimators. Lagged endogenous variables, alone, may cause small bias in finite samples but the estimators are consistent. When both these complications are present, estimators are biased and inconsistent. (This is the case of a regressor and a disturbance term being correlated and is a failure of one of the basic assumptions of ordinary least squares.)

[2]Flax, requiring a slightly shorter growing season, and being better able to withstand excess moisture at early stages would provide a good alternative to wheat during such years.

Another contention which has been raised about Schmitz's traditional model is the use of July 31 farm wheat stocks as an explanatory variable. Since seeding occurs prior to July 31 the use of the variable in this manner assumes farmers know what their farm inventories will be at some time in the future.

Using the distributed lag model, Schmitz obtained an R^2 of .795 but the regression coefficient for lagged wheat acreage was not significant. The Durbin-Watson statistic was inconclusive (1.58)[1] but no attempt was made to check further into the possibility of auto-correlation.[2] The same points of contention can be raised for this model as for the traditional one regarding price of flax and farm wheat stock variables. In addition, the coefficient of determination was lower and the regression coefficients became less significant in the distributed lag model.

In general, the traditional price expectations model performed more adequately in Schmitz's study but some mis-specification of variables seemed present.

Pearson

Pearson saw the necessity for including quota levels in a model of wheat acreage response if such a model were to have explanatory plausability. Variables included in the Pearson model were:

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[1]For four explanatory variables and nineteen observations, 5% significance points were d_L = .86 and d_U = 1.85.

[2]As mentioned previously, auto-correlation in this distributed lag model would lead to biased and inconsistent estimators. The Durbin-Watson statistic is biased towards 2, since ρ the correlation coefficient, is underestimated if auto-correlation does in fact exist.

1. The final realized price for No. 1 Northern Wheat - basis Thunder Bay.

2. Eligible delivery quota rate per specified acre in crop-year 'T-2'.

3. Ending farm carry-over of wheat in crop-year 'T-1'.

4. Eligible delivery quota rate per specified acre in crop-year 'T-1'.

5. Actual wheat deliveries in crop-year 'T-1'.

Ordinary least squares were used to obtain estimates of the regression coefficients. The time period involved was from 1954-55 to 1970-71. An R^2 value of .91 was obtained and all regression coefficients were significant at least at the 10% level.

A major problem encountered was the negative sign on quotas lagged one year, contrary to A priori hypothesis. Later analysis of Pearson's data showed high correlations between the explanatory variables used in the equation. This fact coupled with the reversal of sign on the quota variable is indicative of the presence of multicollinearity.

Another factor detracting from the appeal of the high R^2 in Pearson's results is the use of estimated data figures for the 1970-71 crop-year. When replaced by actual data (unavailable at the time of Pearson's study) a lower R^2 of .88 is obtained.

Since the aggregative wheat acreage model was in fact a very minor sector of Pearson's analysis of quota policy, little criticism can be bestowed on it. The primary importance of the model is the disclosure that quotas are in fact closely related to farmers' seeding decisions.

Anim-Appiah

Anim-Appiah's study centered around the use of aggregate versus disaggregate analyses in wheat and barley acreage response models. Regression analysis was the main estimation technique employed. Several important contributions were made by Anim-Appiah and only those most crucial to the present study are reported.

One major contribution came in the form of a wheat price variable specification. Anim-Appiah realized that the use of final wheat price, lagged the traditional one crop-year, constituted the introduction of an irrelevant variable. This 'T-1' variable represents un unknown quantity since wheat pools do not close in time to facilitate disclosure of final payments prior to seeding.[1] A more proper specification was provided by introducing a two crop-year lag for this variable.

Stocks of wheat and barley were included at their March 31 levels of each year. This is a more realistic specification than is the use of July 31 levels. In addition a dummy variable was incorporated for the condition when wheat stocks exceeded a selected limit.

Linear specification provided better results than did the log form.

The prices of oats and barley were found to be insignificant in explaining aggregate wheat acreage in the prairies. Also - "---the farm

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[1]See Table 2-1, "Dates of Final Wheat Payments".

Table 2-1

Dates of Final Wheat Payments to Farmers (No. 1 Northern)*

Pool Acc't. Year	Date First Cheques Mailed	Date Completed	Amount of Final Payment[1]	Total Price[1]
1957-58	June 9/59	June 30/59	.121	1.621
1958-59	June 17/60	July 11/60	.096	1.596
1959-60	June 26/61	July 19/61	.090	1.590
1960-61	April 12/62	April 26/62	.295	1.795
1961-62	March 27/63	April 15/63	.410	1.910
1962-63	Feb. 17/64	March 6/64	.374	1.874
1963-64	March 8/65	March 24/65	.474	1.974
1964-65	Feb. 25/66	March 9/66	.387	1.887
1965-66	Jan. 17/67	Feb. 1/67	.497	1.997
1966-67	March 28/68	April 9/68	.487	1.987
1967-68	March 28/69	April 8/69	.114	1.814
1968-69	--	--	--	1.700
1969-70	June 17/71	June 29/71	.107[2]	1.680
1970-71	Feb. 16/72	March 2/72	.171	1.671
1971-72			.136	1.596

*Source - C.W.B. Annual Reports

1 - final payment and realized final price after deduction of CWB operating expenses, but prior to deduction of P.F.A.A. levy.

2 - payment from Temporary Wheat Reserves Act.

prices received for flax do not appear to be important in explaining the aggregate wheat acreage seeded in the Canadian Prairies."[1] This latter finding contradicts the results of Schmitz's study regarding price of flax.

Anim-Appiah did not include quotas as a variable but he was aware of their importance as a policy variable, "Wheat stocks can also be used as policy variables. In this regard it is recognized, however, that any such use of wheat stocks can only be indirect, the direct instrument being delivery quotas."[2]

Only a few of the major findings in this study have been presented here. Emphasis has been placed on those currently considered most important. Other results will be presented subsequently to provide comparisons with the present study.

Sahi

Sahi's study was concerned with recursive programming analysis of prairie land use patterns. His choice of estimation technique allowed simultaneous consideration of all six major crops and summerfallow. Quotas were incorporated in the model "In order to bring more realism in the analysis--"[3] and it is this aspect of the study that receives treatment here.

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[1]Anim-Appiah, op. cit., p. 89.

[2]Anim-Appiah, op. cit., p. 142.

[3]Sahi, op. cit., p. 73.

Quotas were not included in the estimation of upper and lower flexibility coefficients but were used as constraint levels in the linear programming analysis. These restraints did not affect most solutions for the 1958 to 1967 period but "--in years of relatively low quota levels (i.e. 1968 and 1969) the restraints became effective in programming solutions; and wheat, oats, and barley acreages were thereby affected."[1] This finding provides some support for the hypothesis that quotas play a role in wheat acreage seeding decisions.

Sahi also analysed the effects of changes in barley prices and quota levels on 1971 forecasts of prairie land use. The results showed identical land use patterns for both a twenty and twenty-five bushel (per assigned acre) quota. However, both of these levels are too high and are actually approximations of 'open' unrestrictive quotas.

Though no concrete findings regarding the influences of quotas on wheat acreage were forthcoming from this study, Sahi showed it was possible to include quotas in a linear programming system. Some support was provided for quota inclusion by the results for 1968 and 1969 where quotas did appear to influence land use patterns.

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[1]Sahi, op. cit., p. 169.

CHAPTER III

THEORETICAL AND STATISTICAL FRAMEWORK

SUPPLY RESPONSE THEORY

This section provides the theoretical basis for the analysis of quota policy. General economic theory is transcribed into specific applications pertaining to wheat acreage supply response.

The production function of a firm (farm) is a mathematical expression of the relationship between the physical inputs and the physical outputs of that firm. The shape and position of a production function for an individual firm is the result of the state of technology of that particular firm. The position along the function at which a certain level of input(s) is used to produce a certain level of output(s) is determined by the relative prices of inputs and outputs, managerial ability and limitations which the firm may have on factors of productions.

The production function of a firm and its supply function are closely related. (In fact the supply function can be derived mathematically from the production function.[1]) A supply function represents the quantity that will be placed on the market at various product prices. A firm's short run supply curve is represented by the portion of its short run marginal cost curve which lies above average variable cost. The long run supply curve is the long run marginal cost curve which is above average

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[1] D. Watson, Price Theory and its Uses, 2d ed. Boston: Houghton Mifflen Company, 1968. p. 193.

total cost. An industry supply curve can be obtained by the horizontal summation of all the individual firms' supply curves if competitive conditions prevail.

Supply response theory is based on the assumption that firms are profit maximizers. Profit maximization is one type of marginal behaviour which allows the use of mathematical techniques in the construction of marginal cost curves. A firm maximizes profits by adjusting the quantity produced and sold so that marginal revenue and marginal cost are equal. However, the farm firm is not necesarily a profit maximizer. Individual preferences for leisure and certain production activities, and the level of capital accumulation are all possible factors which could be important to farmers in making primary production decisions. These factors are difficult to specify and are even more difficult to analyse when concerned with aggregate supply response. This results in the conventional use of the assumption of profit maximization as a convenient approximation to reality.

Standard supply response theory has been developed for perfectly competitive conditions such as large numbers of buyers and sellers in the market with no single buyer or seller influencing price, a homogeneous product, perfect market knowledge and perfectly mobile resources. These conditions do not hold for the Western wheat industry where sales are made to a monopoly board.

It has also been recognized that production decisions are not made in the context of a theoretical static production function but are influenced by conditions of risk and uncertainty.

> Rational decision-making under conditions of uncertainty must rest on subjective estimates of the probabilities of expected prices and costs and, therefore, on the probabilities of expected profits.[1]

These profits, which the farm firm is trying to maximize are determined by total costs and total revenues. Total revenues are the result of two components; prices and quantity sold. However, for western grain farmers the quantity sold can be and has been restricted by delivery quotas and this restriction of the volumes of grain that could be marketed could lead to reduced total revenues for producers.

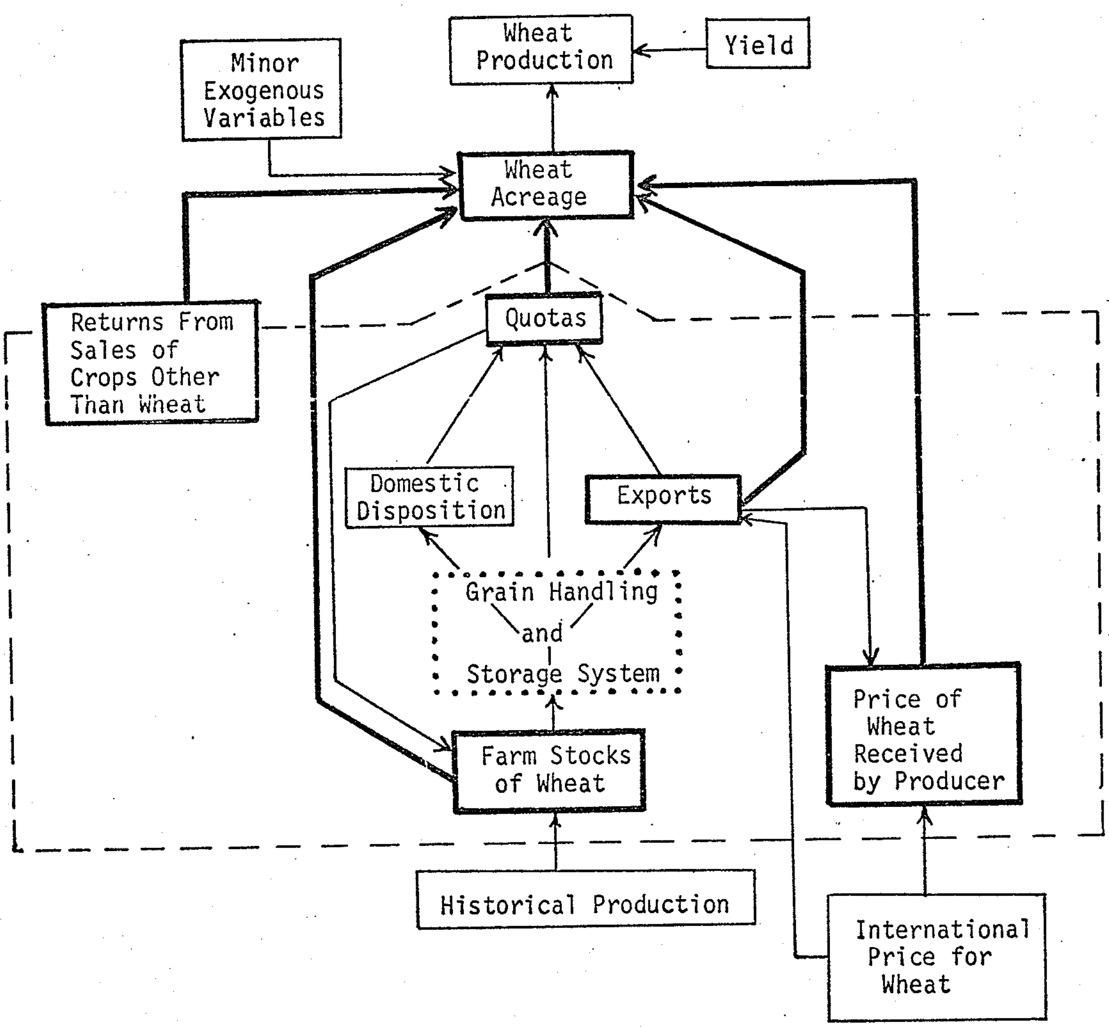
To the extent that reduced total revenues expected by producers are affected by quotas it can be anticipated that producers will respond to quota levels in allocating resources among different enterprises. Grain farmers can therefore be expected to consider their experience and expectations of quotas as a factor when making production decisions (in addition to the traditional supply response factors such as price of the product and prices of competing products.) Thus it is imperative to include quotas in an analysis of production response in Western Canadian grain production, especially when concerned with the supply response of wheat--a commodity marketable only through the Wheat Board and undergoing marketing limitations over the past two decades.

BASIC CONCEPTUAL MODEL

This section presents the conceptual model that will be used to analyse wheat acreage fluctuations in Western Canada. This model is

[1]Watson, op. cit., p. 159.

Basic Model Chart



limited to a broad treatment of factors suitable for aggregative analysis and therefore includes some necessary abstractions from the actual context in which individual farmers reach their annual decisions on wheat acreage to be seeded. It is presented as a flowchart to better illustrate its general form.[1]

Several assumptions underlie the model. It is assumed that several variables are exogenous--that they are predetermined outside the system. In addition it is assumed that farmers in Western Canada first determine how much acreage they will seed to wheat and once this decision has been made, consider how to allot available cultivated acreage to other crops as well as how much to leave lying summerfallow.

While the model is developed broadly so that it may facilitate aggregate analysis it serves as a foundation for disaggregate levels of analysis as well.

Major Factors Affecting Wheat Supply Response

Wheat production in the prairie provinces is the product of two factors; acreage seeded to wheat and yield per acre. The acreage seeded to wheat is the variable which is adjusted by producers in response to economic factors. Yield, a function of technological advancement and weather conditions, can not be adjusted with any precision and is

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[1]See 'Basic Model Chart'. p. 26.

considered exogeneous for the purposes of this study.[1]

The basic conceptual model hypothesizes that acreage seeded to wheat is influenced by six groups of factors. The primary group can be labeled as prices of wheat. Returns from alternate crops, Canadian wheat exports, inventories of wheat held by producers, and quotas' restrictions of sales opportunities are also major groups of factors influencing acreage devoted to wheat. A sixth group of minor factors, such as moisture prior to seeding and producers' preferences for certain production activities can also be hypothesized to affect wheat acreage, but not in a very significant manner.

The effects of wheat price on wheat acreage are described by economic supply response theory. As the price of the product increases the amount of the product offered for sale increases. Since yield is abstracted from, acreage rather than actual physical production becomes the response variable. Therefore as wheat price increases, the acreage seeded to wheat increases.

The returns from other crops[2] are transcribed into wheat acreage

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[1]Economic factors will also influence producers to attempt to affect yield. In addition physical factors such as moisture conditions during seeding to some degree affect acreage. However seeded acreage is the best available variable for examining producer response since it is believed to reflect the producers' willingness to respond to economic factors more precisely than does actual production. (See Chapter 1--'Objectives of the Study').

[2]An Extension of this 'alternate returns' concept could include other production possibilities such as beef and hog enterprises.

fluctuations through the economic concept whereby rival products compete for the same input.[1] In the case being considered the scarce input is land. Producers' decisions on how much wheat to seed are carried out in reference to other possible sources of revenue from that acreage. The primary alternatives in Western Canada, in terms of production activities, include the growing of barley, oats, rye, rapeseed and flaxseed. As the price of any of these competing crops increases, the acreage seeded to wheat declines and the acreage of the alternate crop increases.[2]

Exports of Canadian wheat are important in affecting wheat acreage by reflecting foreign demands for Canadian wheat back to the producers. As wheat exports rise an optimistic outlook prevails among producers and wheat acreage increases. When exports decline, an outlook of pessimism is generated with corresponding declines in wheat acreage. While the nature of this outlook in the farmers' decision-making environment is conditioned by media reports on various topics including prospective exports (sales commitments) as well as actual exports, it is assumed for purposes of this study that actual exports are a sufficient indicator of the outlook at the aggregative level. Since export contracts must be filled by the delivery of grain, actual physical exports and media-reported sales commitments are assumed inseparable in terms of their effect on wheat acreage for the purposes of this study.

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[1]Watson, op. cit., p. 271.

[2]This is not inconsistent with the earlier assumption that the wheat acreage seeding decision is primary and remaining acreage is later alloted to other uses. It does hypothesize that, when deciding on how much acreage to seed to wheat, producers refer to prices of other crops.

In deciding on how much acreage should be channeled into wheat production, farmers' relate directly to physical on-farm wheat stocks. Adjustments in production are made in the standard manner of response to inventory build-up or depletion. When farm wheat inventories are high, potential wheat acreage is diverted to alternate uses. When farm stocks are low, acreage seeded to wheat increases. The physical proximity of stocks to producers enhances the wheat inventory effects on wheat acreage.

The effects of quotas on wheat acreage occur because of the restrictions imposed on the amount of wheat which can be commercially marketed. Restriction of quantity is reflected in restricted wheat deliveries to country elevators and reduced total revenue for producers, *ceteris paribus*.[1] As in the case of farm wheat stocks, quotas are very easily and directly related to by producers, since increases in quotas result in increased cash receipts for them. Thus high quotas result in large wheat acreages and low quotas, which restrict wheat marketings, result in reduced wheat acreages.

It is acknowledged that a variety of factors such as spring moisture conditions and producer preferences for growing wheat will influence the acreage seeded to wheat. However, it is assumed that only minor fluctuations in wheat acreage would stem from these. Therefore they are not relevant in the conceptual model being devised and are henceforth excluded.

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[1]See Chapter 3. 'Supply Response Theory'.

Institutional Factors

Four of the five groups of factors important in influencing wheat acreage operate entirely within an institutional framework established by the Federal Government and the Canadian Wheat Board. (This is depicted in the model chart by the large dashed rectangle). That is to say, these four groups (price of wheat, exports, stocks, quotas) are controlled by the Federal Government and the Wheat Board. Returns from crops other than wheat are partly within and partially excluded from this sector since all are Wheat Board quota-regulated but can be marketed outside of Canadian Wheat Board control. This institutional framework can be used to manipulate the factors within, in order to arrive at a 'desirable' level of wheat production (whether it be aggregate, regional, or on individual farm basis).

As one operating mechanism within this institutional set-up there exists the 'Commercial Grain Handling and Storage System'. (This is depicted in the model chart as the small dotted rectangle). Included in this system are Government policies on commercial inventory holdings and rail-line operating procedures. By using these institutional 'tools' the groups of factors affecting wheat acreage can be manipulated.

Inter-relationships Within the Acreage Response System

Five groups of variables (price of wheat, returns from other crops, exports, quotas, farm wheat stocks) are hypothesized to have direct and substantial effects on wheat acreage. These five groups of variables are also related to other features in the Western Grains Industry not directly affecting wheat acreage as well as being related to one another. The most important of these relationships is traced out for each of the five groups in turn. It is assumed, except when stated otherwise, that institutional aspects such as commercial inventory policy are held constant.[1]

The price of wheat received by producers, being based on Canadian Wheat Board revenues, is determined by three factors; the international price of wheat, Canadian exports of wheat and domestic commercial sales of wheat.[2] The international price, a result of international supply and demand conditions, is treated as exogeneous.[3]

The returns from crops other than wheat are not directly related to other facets of the prairie wheat industry, for the purposes of this study, and are therefore treated as independent.

Exports of wheat, besides being a type of 'opportunities' variable for producers, have an effect on

1. the price received by producers, and,
2. the quota level advancement.

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[1]'Commercial inventories' are grains in storage at country elevators, inland terminals and at the export terminal points of Vancouver, Churchill and Thunder Bay. As such they are to be differentiated from 'Farm Stocks' which are inventories held by producers on farms.

[2]The link between domestic sales and price has not been included in the chart.

[3]Canada's share of world wheat markets is one-fifth and in reality Canada does influence the world wheat supply function. However it is assumed for the purposes of this study that Canadian wheat does not affect international wheat price. Such detailed analysis of international supply and demand conditions was beyond the scope of this study.

As exports increase and grain moves from the commercial storage system to foreign destinations, quotas are increased in order to move farm stocks into country elevators (assuming no changes in commercial inventories).

Exports are associated with the international price for wheat. When the international price is high there is additional incentive for the Canadian Wheat Board to increase exports. In addition exports are related to, and to some extent, influenced by, farm wheat stocks. (When exports increase, farm stocks decrease proportionately if there is no change in the level of commercial stocks. If farm inventories are high, there is political pressure on the Canadian Wheat Board to increase exports).

Farm stocks of wheat stem from historical production and can be disposed of in three ways; they can be exported, used domestically, or if inventory policy changes and elevator space permits, they can be moved into commercial storage. All three routes of disposal require advancement of quota levels. This advancement, providing the wheat is actually delivered to country elevators, depletes farm stocks. Therefore a circular reaction pattern is generated between quotas and stocks.

Quotas, besides directly influencing wheat acreage, reduce farm stocks (as reported above). They are directly affected by exports and domestic sales providing there is no change in commercial inventory holdings. If inventory policy is changed, quotas may be affected in two additional ways. Quotas may advance in order to build up commercial inventories, or they may remain constant while commercial inventories are lowered by exports or domestic sales.

These changes in commercial inventories provide buffer effects between quota advancement, farm stock depletion, and export levels. Other intermediary effects are also inserted into the relationships between these three groups of variables by other aspects of the 'Grain Handling and Storage System', (such as the railway system). For this reason there is an incomplete correspondence between these three groups of variables (quotas, exports, farm wheat stocks) and all three serve as decision factors for prairie wheat producers. Therefore quotas are necessarily included in the conceptual model along with other decision variables.

Summary of the Model

Five major groups of factors influence wheat acreage in the prairie provinces. Operating within an institutional framework, these groups are related to one another and to other facets of the wheat industry. These relationships are simple in some cases and very complex in others. Conceptually all five groups warrant inclusion in a wheat acreage response model. The model developed can be functionally expressed as:

$$Aw = f(Pw, Roc, Ex_w, Sw, Qw)$$

where:

Aw = Acreage seeded to wheat

Pw = Price of wheat

Roc = Returns from other crops

Ex_w = Exports of wheat

Sw = Farm wheat stocks

Qw = Quotas under which wheat deliveries have to be made

Due to its generalized form the model is valid for various levels of analysis in either the aggregate or disaggregate approaches.

STATISTICAL MODEL

Choice of Estimation Technique

In order to test the conceptual model developed it becomes necessary to examine various possible techniques available for conducting such analysis. In essence the problem is one of supply response analysis. Techniques available include functional analysis, direct estimation of a supply curve through regression analysis, surveys, budgeting and engineering approaches, and various forms of linear programming. Most of these methods were quickly discarded due to inherent limitations.

Direct estimation of a supply function from a production function was deemed infeasible due to anticipated difficulties of first estimating a production function with quotas as a component. Survey techniques, though useful for short term prediction, are not suited to policy oriented analysis. The budgeting approach was rejected because the subjectivity which enters into establishment of 'desirable' levels of output for a farm. The engineering approach, the construction of cost curves from a firm's data records, was considered as inappropriate for modification to quota response analysis. As a result of these rejections the main decision was between linear programming and regression analysis.

Recursive programming. This form of linear programming is capable of predicting the actual, rather than optimum, behaviour of firms. A time dimension is included through the calculation of flexibility coefficients which place maximum and minimum bounds on activity levels and/or constraint levels.[1] Aggregation bias problems occur in expanding individual firm results so aggregate or regional based models are generally used.[2]

Recursive programming solutions are extremely dependent upon the values calculated outside the linear programming system for the upper and lower flexibility coefficients. Since these coefficients are estimated in many cases through regression techniques the same statistical problems (multicollinearity, insufficient degrees of freedom) occur here as in the direct estimation of supply curves through regression techniques.

Recursive programming can be utilized to analyse models of multi-product firms. (All six major crops could be analyzed simultaneously as in Sahi's study). In addition this technique allows incorporation of structural changes such as LIFT.

Regression analysis. This technique enjoys the advantage of simplicity and ease of analysis. Accounting for structural change is a problem inherent in regression analysis. Some changes can be analysed through inclusion of dummy variables but this method can not readily be employed if the basic features of a system undergo complete modification. In addition statistical problems of multicollinearity and insufficient

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[1]Recursive programming is to be differentiated from multi-period programming which incorporates time in the form of several production periods within the actual linear programming model.

[2]Even with an aggregate model aggregation problems still occur due to the distribution of fixed factors among firms.

degrees of freedom plague users of regression techniques.

Regression analysis is best suited to analysis of single product firms. Simultaneous equation systems can be employed for multi-product firm analysis but simplicity of analysis is sacrificed.

Reasons for selection. After a detailed consideration of regression techniques and recursive programming, regression analysis was chosen for the estimation of the model. This technique would be applicable to both aggregate and disaggregate forms of analysis whereas recursive programming is subject to aggregation bias when individual firm results are expanded. Though regression has some disadvantages, most of these would also appear in the calculation of flexibility coefficients for a recursive programming model. In addition, supply response studies using both methods found that regression produced results comparable to complex linear programming models.[1]

General Estimation Procedures

Single equation least squares was deemed to be the most appropriate manner of analysing the conceptual model which incorporated the effects of Canadian Wheat Board quotas on wheat acreage.

Three levels of analysis will be conducted. The conceptual model developed earlier in the Chapter will be estimated using aggregate Western Canadian time-series data. Special consideration will be given to the possible effects of various individual types of quotas.

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[1]W. N. Schaller and G. W. Dean, Predicting Regional Crop Production (U.S.D.A. Technical Bulletin #1329, April 1965).

The second section will attempt to discover if there have been variations in response to quotas on the basis of productivity factors. The prairie provinces will be sub-divided on the basis of 'Commercial Farming Zones of Western Canada'[1] and time series analyses will be performed on individual regions.

It is anticipated that in the aggregate analysis, problems of multicollinearity will be severe due to the presence of variables such as farm wheat stocks, wheat exports, and quota levels which are expected to be quite highly correlated. The third section of analysis will attempt to combine cross-section individual producer data and aggregate time series data in order to provide extraneous estimators for the coefficients of independent variables (such as farm wheat stocks).

Details of the estimation procedures will be presented along with the results of analysis in Chapter IV.

Variable Specification and Data Availability

The conceptual model developed earlier in the Chapter presented the hypothesis that five groups of variables influence the acreage seeded to wheat. These include the price of wheat, returns from other crops, wheat exports, farm wheat stocks and quotas. The exact form of the variables within these groups had not been specified due to the general nature of the model. This section reports the specific forms chosen for the variables, the availability of data corresponding to

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[1] As developed by the 1961 Census of Canada.

these variables and the difficulties encountered in collection and preparation of data for analysis. The presentation corresponds to the three levels of analyses to be attempted.

Section 1 - aggregate time series analysis. This section of analysis had to be limited to the period from 1958 to 1969 due to lack of data on quotas prior to 1957 and due to the LIFT program in 1970. Data requirements on the following variables were therefore limited to this 12 year span.[1]

1. Wheat Acreage

The dependent variable, aggregate annual wheat acreage for Western Canada, was readily accessible from the Canadian Wheat Board annual reports. (These figures originate from Statistics Canada and are not the acreages reported by farmers when making permit book applications). The acreages used include durum wheat since in most years the formula for calculating specified acreage included durum.

2. Price of Wheat

Several specific variables were available for use as the wheat price received by farmers. Among the possibilities were; the final (or initial) price of No. 1 Northern, the final (or

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[1]An attempt was made to extend the analysis into the years of assigned acreage quotas by conversion of these levels to a specified base. This proved infeasible, however.

initial) price of some lower grade, or some average of the above--simple or weighted by volumes of sales. The price selected was the final realized price[1] for No. 1 Northern Wheat--basis in store at Thunder Bay (source: Canadian Wheat Board annual reports). This choice was based on the ready availability of data, and on the knowledge that, in practice, the No. 1 grade price serves as the basis for lower grades and is also related to Dürum price.

For this particular variable a lag of two crop years was used in the time series regressions rather than the standard lag of one year generally used in studies of this nature. The reason for a two year lag stems from the operating procedures of the Canadian Wheat Board. The final payment to farmers (after a wheat pool is closed) is not generally made until approximately two years after a crop has been seeded. As an example, the final payment on the 1961-62 crop year pool was made on March 27, 1963; just prior to the seeding of the 1963-64 crop.[2] (This form of lag for wheat price was specified in another study of supply response by Anim-Appiah).[3]

3. Returns From Other Crops

Three specific variables were used from within this general

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[1]Final prices are more representative of total returns from wheat sales than are initial payments. Thus final prices are more likely to be a decision variable for wheat producers.

[2]See Table 2-1; "Dates of Final Wheat Payments to Farmers".

[3]Anim-Appiah, op. cit., p. 61.

group of hypothesized wheat acreage decision factors. These were the prices of barley, oats, and flaxseed. The 'price of barley' variable used was the final realized price for No. 3 Canada Western 6-row barley-basis in store Thunder Bay (source: Canadian Wheat Board annual reports). A two crop-year lag was incorporated for this variable (in direct relation to the lag used for the price of wheat variable) due to the delay in final payment receipts by producers.

The price of oats variable used was the final realized price for No. 2 Canada Western - basis Thunder Bay (source: Canadian Wheat Board annual reports). As for the cases of wheat and barley price specifications, a two crop-year lag was used.

Since flax is a non-board grain, flax price appeared to justify special consideration in terms of lagged effects on wheat acreage. It was assumed that the monthly average price for April was the most recent flax price available to farmers prior to seeding. Data on this variable was obtained from the Quarterly Bulletin of Agricultural Statistics published by the Dominion Bureau of Statistics.

Two price variables which might have been included were the price of rapeseed and the price of rye. Rapeseed was not included in the analysis since this crop was of little economic importance prior to 1964 and no consistent data on prices was available prior to that year. However any future analysis on wheat acreage response in more recent years should include this variable due to the large acreages seeded to this crop over the past few years. Rye was excluded from the analysis due to the relatively small and fairly constant acreages of this crop historically.

4. Wheat Exports

In the conceptual model it was hypothesized that physical wheat exports and reports on wheat sales to foreign countries could not be differentiated in terms of their effects on wheat acreage. Therefore physical exports of wheat (and wheat flour) were specified for use as a variable and were incorporated with a one crop-year lag (i.e. the physical exports from August 1st, 1957 to August 1st, 1958 were expected to influence the amount of wheat seeded in the spring of 1958). Since most major grain sales are announced well in advance of the actual physical shipment it is assumed that farmers would have some prior knowledge of what exports should be during the April to August period. The data source was the Canadian Wheat Board annual reports.

5. Quotas

In development of the conceptual model the hypothesis was made that quota levels, in general, were considered by farmers when making their wheat acreage seeding decisions. The exact nature of these quota levels had not been established since several forms of delivery quotas have been used to regulate wheat deliveries. The most important up to 1969 were the unit, the specified acreage and the supplementary quotas; the workings of which have been outlined in Chapter II.

The specified acreage quota was of greatest importance in terms of facilitating grain deliveries and was thus expected to be the most important quota variable. A previous study (Pearson's)[1] utilized the July 31st (i.e. crop-year end) level of unit and specified acreage quotas. However since seeding decisions are made prior to this date, the April 30th level would appear to be a more appropriate decision variable. Although equalization of delivery quotas among farmers generally occurred by the end of each crop-year, levels of specified acreage quotas varied between delivery points at April 30th. As a result an 'average specified acreage quota level' had to be calculated for this date.[2] A difficulty occurred in the calculation of a quota level for April 30th, 1962. In that year the Canadian Wheat Board authorized 'open' delivery quotas for all producers as of April 12th. Theoretically the 'open' quota means infinity and a level replacing it had to be calculated in order to provide continuity in the explanatory variables for

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[1] Pearson, 'Analysis of Quota Policy'.

[2] The method of calculation is outlined in Appendix 'A'. The primary data sources were the Canadian Wheat Board annual reports from 1957 to 1969.

all years.[1]

Though it was believed that the 'average specified acreage quota level' would serve as an extremely useful variable in explaining aggregate wheat acreage in the prairies, another specified acreage quota variable was explored as well. This variable consisted of the maximum level to which the specified acreage quota level had advanced at any delivery point in Western Canada by the end of April. The data for this 'maximum specified acreage quota level' was obtained from Canadian Wheat Board annual reports. The reason for attempting this specification of the quota variable was due to the possibility that, because of expected equalization of quotas, farmers might have been reacting to the 'maximum' quota level attained in the prairies rather than the 'average'.[2]

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[1]A level of 5.96 bushels per specified acre was calculated in the following manner. The farm stocks of wheat at August 1st, 1961 and the wheat harvested later that fall were summed to provide the total deliverable wheat supplies. This figure was then divided by the prairies' specified acreage for that year. The calculated value of 5.96 represents the level to which quotas would have had to advance in order for farmers to dispose of their entire farm stocks of wheat. (No allowance was made for wheat required for seeding purposes. It is believed that grain for seeding purposes is not reported by farmers when responding to questionnaires so these stocks would not have entered into the stocks values initially). In later stages of the project the sensitivity of this 5.96 level was analysed and this particular level was accepted as being a good approximation of the quota position at April 30, 1962.

[2]If the analysis shows this variable to be less significant than 'average' quotas, this would tend to indicate that there is imperfect knowledge by producers of quota levels elsewhere in Western Canada or that producers discount the possibility of quota equalization.

During the period 1954 to 1969 the 'unit quota' was used by the Canadian Wheat Board in order to provide a delivery advantage for small producers. The definition of a 'unit' in terms of bushels of various grains deliverable was altered during this time period. A dummy (0-1) variable was constructed to analyse whether the shift from three bushels wheat per unit to four bushels wheat per unit had any significant effect on wheat acreage. In addition the unit quota was converted to a specified acreage base for purposes of analysing this particular quota.[1] For both the actual unit quota and the dummy variable a one crop-year lag was used in the analysis.

Supplementary quotas for wheat were only in effect for two out of the twelve years under analysis. The levels of these quotas at April 30th were converted to a specified acreage base and were only used in the analysis in conjunction with specified acreage quota levels. Due to their limited use, they were not treated as a separate variable in regressions.

6. Farm Wheat Stocks

Previous studies of wheat acreage supply response had used the July 31st level of farm wheat stocks as an explanatory

[1]The conversion was carried out by multiplying the number of bushels of wheat deliverable under the unit quota by the number of permit book holders and then dividing by the total specified acreage in the prairies for that year.

variable. Since seeding occurs prior to this date the same argument holds as applied to the quota variable. A more proper specification is the April 30th level of farm wheat stocks. These were calculated by adding the producer deliveries to the Canadian Wheat Board in May, June and July to the August 1st level of farm stocks, for each year in the analysis.[1] This method does not allow for disposal of wheat through channels other than the Canadian Wheat Board. Data on both deliveries and stocks was obtained from the Canadian Wheat Board reports.

7. Other Variables

The variables thus far specified correspond directly to the basic conceptual model previouslydeveloped and the statistical analysis centered around these. However due to the importance of trend variables in previous studies it was felt that a time trend should be examined in conjunction with the hypothesized important variables. When included, it consisted of a sequence of whole numbers starting at unit, and increasing by one for

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[1]Another method of calculating the April 30th stocks level consisted of subtracting April deliveries from March 31st levels (obtained from the Quarterly Bulletin of Agricultural Statistics). The accounting procedures used by Statistics Canada in arriving at a March 31st level of stocks are such that the July 31st level is a more accurate starting point for calculation of the required level of stocks. Both methods were used in the analysis but the method using August 1st stocks as the starting point provided better results in terms of statistical significance of the variable and R^2.

each year in the analysis.

Section 2 - regional productivity analysis. The second section of the analysis was designed to discover whether any variations in response to quotas in terms of wheat acreage changes could be attributable to productivity factors associated with different farming regions.[1] Since previous studies did not concern themselves with this aspect an initial step consisted of the division of Western Canada on the basis of regions differing in natural attributes that can be related to the agricultural potential. The choice to use "Commercial Farming Regions" (as established in the 1961 Census of Canada) rested on the need to acquire a relatively simple and yet meaningful proxy for productivity. This section of analysis hypothesized variations in response to quotas between various commercial farming regions.

A random sample of twenty grain delivery points was chosen from each of the five regions and the average wheat acreage per farm was calculated for use as the dependent variable.[2] Delivery point acreage data was obtained from the Canadian Wheat Board "Summary of Seeded Acreages". The explanatory variables were limited to two; the specified

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[1]Standard practice seems to be the sub-division of the prairies into provincial sectors as a general first stage of disaggregation. However provincial boundaries are institutional and do not necessarily correspond to any productivity factors. Therefore analysis on a provincial basis was not attempted.

[2]The 'Beef' and 'Dairy' regions were combined in one 'Cattle' region.

acreage quota level at April 30th lagged one crop-year and the time trend. Though it was realized that price is perhaps the single most significant variable it was excluded from this section since responses to quotas were being analysed. (Such an exclusion does bias the regression coefficients. However it was assumed that the bias injected into each coefficient would be approximately equal and would not influence testing of the quota variable coefficients). This section was limited to nine years since acreage data on a delivery point basis was not available from the Wheat Board or other sources prior to 1961.

Section 3 - cross-section and time series analysis. It was anticipated that severe problems of multicollinearity would be encountered in Section One of the analysis. One method around the multicollinearity problem[1] is through the extraneous estimation of regression coefficients, generally making use of cross-sectional information.[2] This section of analysis was intended to provide an estimated value for the farm wheat stocks coefficient to be inserted into the time series analysis of Section One.

Ideally a coefficient for quota levels should have been extraneously estimated, since quotas were perhaps discarded from previous studies' regressions due to multicollinearity. However data on quotas

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[1]The multicollinearity problem is covered in more detail in the next section, 'Econometric Estimation Problems'.

[2]J. Johnston, Econometric Methods. 2d. ed. New York: McGraw-Hill Book Company, 1972.

and acreages on a cross-section individual producer basis were not available. Cross-sectional data on farm stocks and acreages were available for recent years from Statistics Canada, but were limited to Manitoba. This limitation was undesirable but it was felt that the Manitoba data would provide results that were reasonably close to the prairie province situation.

Additional treatment of variable specification and data requirements is deferred to Chapter 4 since Section One results will further determine the requirements and procedures of Section Three analysis.

Econometric Estimation Problems

With the least squares estimation technique employed in the analysis it was anticipated that three econometric problems might occur and have to be overcome; multicollinearity, autocorrelation, and heteroscedasticity.

Multicollinearity[1] is the problem of highly correlated explanatory variables. This may result in large errors in the coefficients, correlation among the errors, and large sampling variances. The estimates derived when multicollinearity is present are very sensitive to the particular sample of data and coefficients shift as new data is added.

Incorrect omission of variables with apparently low explanatory power often occurs. (This could conceivably be the reason for rejection of quota levels as an explanatory variable in earlier studies). The problem of multicollinearity is directly related to small sample size

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[1] Johnston, op. cit., pp. 159-168.

and can not be solved without the acquisition of new data. Since the time series analysis in this study is very limited (12 years) an attempt was made to extend the data block into the years of assigned acreage quotas--however this proved infeasible.

Barring the extension of the data series it is possible to try and circumvent the problem at hand through several techniques. The transformation of the data block (perhaps through first differences) is one method but it incurs the possibility of building autocorrelation into the series.

Extraneous estimation of a coefficient for a variable highly correlated to other explanatory variables, through cross-sectional analysis, is another technique.[1] This method was considered most appropriate if multicollinearity did in fact create problems.

Autocorrelation[2] is the problem of correlated disturbance terms. This statistical problem does not bias the estimators of the population parameters (α and β) but does make these estimators inefficient--that is--they are not minimum variance estimators. The standard methods of calculating the variances of the coefficients are no longer appropriate but provide a bias towards zero with the result that T-tests seem more significant than they actually are. Predictions from models with autocorrelation disturbance terms will be inefficient since inefficient estimators of the true population parameters are used in the prediction and also no account of previous disturbances is taken in making the prediction.

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[1]Ibid., pp. 221-228.

[2]Ibid., pp. 246-249.

The Durbin-Watson statistic is generally used in testing for the presence of autocorrelation. Values of the statistic close to two are indicative of no autocorrelation; values approaching zero indicate positive autocorrelation while negative autocorrelation is indicated by a statistic approaching four. Durbin-Watson tables start with 15 degrees of freedom and since most of the time series work in this study was limited to twelve years the Durbin-Watson test for autocorrelation did not in fact hold much significance. Instead of testing whether the statistic indicated the presence of autocorrelation for each regression, it was decided to try and obtain a value of close to two with the model. If the final model did not produce a "satisfactory" Durbin-Watson--then transformations of the data would be run to try and suppress autocorrelation.

Heteroscedasticity[1] is the problem of unequal variances of disturbance terms and is generally a cross-section and not a time-series problem. The estimators are still unbiased as in the case of autocorrelation, but are no longer minimum variance and as a result interject bias into the T-tests. The test for heteroscedasticity consists of running the regression, grouping the distrubances into ranges and performing an F-test on the sums of squared disturbances:[2]

$$\frac{\text{Large } \Sigma\varepsilon_i 2/n-p-1}{\text{Small } \Sigma\varepsilon\ 2/q-p-1} = F$$

Only the final regression model will be tested for heteroscedasticity.

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[1] Ibid., pp. 214-221.

[2] Ibid.

CHAPTER IV

PROCEDURES AND RESULTS OF ANALYSIS

This Chapter presents the procedures followed in conducting the analysis and the results obtained.

Except when specified otherwise, all results are for the linear specification in single equation least squares regression. The Chapter is subdivided to correspond to the three major sections of analysis.

SECTION 1 - AGGREGATE TIME SERIES ANALYSIS

This section presents the details of analysis and statistical results of running single equation least squares[1] on a variety of variables that were hypothesized to influence aggregate wheat acreage in Western Canada. According to the conceptual model presented in Chapter III, factors influencing the acreage seeded to wheat can broadly be divided into five groups:

1. Price of wheat
2. Returns from other crops
3. Wheat exports
4. Farm wheat stocks
5. Quotas under which wheat deliveries had to be made

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[1] An attempt was made to develop a supply response model for all six major crops and to estimate it using two stage least squares. Though such a model was conceptually developed, estimation proved impossible due to the limited block of observations available.

Each group is composed of one or more individually specified variables and it was these, rather than the broad groupings, that were introduced into the regressions.

The analysis was conducted in a manner which was initiated on an extremely simple level (with price of wheat as the only explanatory variable) and which proceeded to add variables hypothesized to have an impact on wheat seeding decisions.

This step-by-step construction of a satisfactory regression equation, corresponding to the conceptual model developed earlier, allowed for a close check on the anticipated problem of highly correlated explanatory variables and should have resulted in no incorrect omission of variables.

The analysis was carried out based on the hypothesis that the price of wheat would have been the variable inducing most acreage response. However in some regressions price was excluded, in order to provide a check on whether this basic economic principle of supply applies in the case of wheat acreage response.

A traditional rather than distributed lag model was assumed initially while at a later stage quota and price expectation models were explored.

In the tables of results presented, the T-value of each coefficient is bracketed above the coefficient. The level of significance is also indicated for each coefficient. Three asterisks indicate that the coefficient is statistically significant at the one percent level of confidence, two asterisks indicate significance at the five percent level, one asterisk at the ten percent level, and "°" indicates significance at the twenty percent level of confidence. Signs on coefficients not conforming to a priori hypotheses are indicated by a lower case "x", and this feature is noted at the bottom of each table.

Preliminary Regression Specifications

Early stages of analysis included only three explanatory variables; the average specified acreage quota level at April 30th; the final realized price of wheat lagged two crop-years; and exports of wheat lagged one crop-year. The results are presented in Table 4-1. As expected, price carried a high degree of significance (at the 1% level of confidence) in all four regressions in which it occurred. The sign on the coefficient was positive in all cases as predicted by standard economic theory, indicating that increases in wheat acreage occurred following increases in the price of wheat.

The average specified acreage quota level was extremely significant (1% level) when used in a simple regression as an explanatory variable (Equation #3) and retained significance at the 10% level when included with price of wheat in a multiple regression (Equation #2). In both cases the sign on the quota variable was positive as hypothesized indicating increased wheat acreage in response to increased quota levels at April 30th.

Exports of wheat were significant at the 5% level when included with price and the coefficient carried the expected positive sign as well (Equation #4).

However, when price of wheat, specified acreage quota levels,

Table 4-1

Preliminary Regression Results
of Estimating the Aggregate Model

Equation Number	Constant Term	Regression Coefficients: Price of Wheat (T-2)	Average Specified Acreage Quota Level (T-1)	Exports of Wheat (T-1)	R^2	Durbin Watson	Standard Error of Estimate
1	0.41	(5.94)[1] 14.38***			.77	2.00	1.30
2	4.47	(3.57) 10.48***	(1.94) 0.56*		.84	2.33	1.15
3	19.64		(4.07) 1.25***		.62	0.97	1.70
4	2.96	(5.24) 10.97***		(3.09) .009**	.89	1.63	0.95
5	4.24	(3.97) 9.91***	(0.82) 0.23	(2.14) .008*	.90	1.79	0.98
Means:		1.80	5.36	386.2			
Units:		Dollars per bushel	Bushels per specified acre	Millions of bushels			

(1) Bracketed figures are t-values

and export levels were all included in the same regression, quotas become insignificant and the significance of exports dropped to the 10% level (Equation #5). This indicated at an early stage that the anticipated problem of multicollinearity was present. However, this early stage of analysis demonstrated that quota levels seem to be instrumental in farmers' wheat acreage seeding decisions and the omission of this variable from other studies using regression techniques has probably been due to econometric difficulties in estimation. High R^2 values and Durbin-Watson statistics close to 2.0 in most cases were encouraging, suggesting high explanatory powers in these three variables and possibly no autocorrelation problems.

The Multicollinearity Problem

In order to obtain a better perspective of the seriousness of the multicollinearity problem, farm wheat stocks were added to the preliminary regressions. (Table 4-2). When this variable was included with price of wheat and specified acreage quotas, both price and quotas lost some significance and the farm wheat stocks coefficient turned out to be insignificant. (Equation #1). The positive sign on this latter coefficient was indicative of multicollinearity since a negative correlation existed between stocks and wheat acreage. When exports were added (Equation #2) the right sign appeared on the stocks variable (though still insignificant) but a reversal of sign occurred on the quota variable. Dropping the quota variable at this stage (Equation #3) had the effect of making stocks slightly significant (20% level of confidence) and the correct negative sign was present. Since the R^2 of this

Table 4-2

Results of Estimation When Farm Wheat Stocks are Included

Equation Number	Constant Term	Regression Coefficients: Price of Wheat	Average Specified Acreage Quota Level	Exports of Wheat	Farm Wheat Stocks	R^2	Durbin Watson	Standard Error of Estimate
		(2.82)	(1.45)		(0.16)			
1	4.47	10.20**	0.60^{o}		.001$_{x}$	.84	2.33	1.29
		(4.06)	(0.41)	(2.48)	(1.17)			
2	4.14	11.70***	-0.19$_{x}$	.010**	-.006	.917	1.63	0.96
		(5.51)		(3.23)	(1.46)			
3	4.55	10.87***		.009**	-.004^{o}	.915	1.65	0.90
Means:		1.80	5.36	386.2	337.4			
Units:		Dollars per bushel	Bushels per specified acre	Millions of bushels	Millions of bushels			

"x" - denotes a sign opposite to <u>a priori</u> hypothesis.

regression was high (.915), this specification might have been accepted if the procedure of deleting variables which turn out insignificant had been followed. However, since quotas had shown a high level of significance when not in the presence of highly correlated variables such as farm wheat stocks and wheat exports, it was felt that omission of this quota variable was in fact incorrect and some way around the serious multicollinearity problem would have to be found.

A Check on the Unit and Supplementary Quotas

Before proceeding to try and solve the statistical problem of high correlation in the explanatory variables the unit quota and supplementary quota variables were included in the analysis to discover whether any of the variations in wheat acreage could be attributable to these other forms of quotas which were in effect during the time period under consideration. It was hypothesized that unit quotas, unlike the specified acreage quota, would not be a significant factor due to the very limited year-to-year variations in this variable. In addition, supplementary quotas, due to their infrequent usage, were hypothesized to be of little importance in explaining fluctuations in wheat acreage. The unit quota was first specified as a dummy variable (to account for the change from three to four bushels of wheat per unit). When included with price and specified acreage quotas, the dummy variable coefficient proved insignificant (Table 4-3, Equation #2). Another specification included the actual unit quota (converted to the specified acreage base) but besides being insignificant the coefficient also carried the wrong sign (Equation #3). A third attempt included the unit and specified

Table 4-3

Results of Estimation When Unit and Supplementary Quotas are Included

Equation Number	Constant Term	Price of Wheat (T-2)	Average Specified Quota Level (T-1)	Dummy Unit Quota (T-1)	Actual Unit Quota (T-1)	Specified and Unit Quotas (T-1)	Specified and Supplementary Quotas (T-1)	Specified and Unit and Supplementary Quotas (T-1)	R^2	Durbin Watson	Standard Error of Estimates
		Regression Coefficients									
1	4.47	(3.57) 10.48***	(1.94) 0.56*						.84	2.33	1.16
2	5.85	(1.91) 9.42*	(1.50) 0.64[o]	(0.28) 0.36					.84	2.34	1.21
3	9.89	(3.56) 10.46***	(1.57) 0.47[o]		(1.00) -5.58[x]				.86	2.26	1.15
4	3.83	(3.57) 10.59***				(1.87) .547*			.84	2.33	1.16
5	3.97	(3.19) 11.4**					(1.11) 0.317		.80	2.59	1.29
6	3.55	(3.19) 11.5**						(1.06) 0.308	.80	2.58	1.29
Means:		1.80	5.36	--	0.88	6.24	5.68	6.57			
Units:		$ per Bushel	Bushels[1]	--	Bushels[1]	Bushels[1]	Bushels[1]	Bushels[1]			

(1) Per specified acre

"x" - denotes a sign opposite to <u>a priori</u> hypothesis.

acreage quotas as a summation (Equation #4) but no appreciable difference occurred over the inclusion of specified acreage quotas by themselves.

The results of these specifications indicate, as had been hypothesized, that unit quotas did not have a significant effect on wheat acreage during the period analysed. It would seem that producers came to accept the unit quota as a standard phenomenon and anticipated that this quota would regularly be implemented near the beginning of each new crop year. In addition, shifts in the formula of a 'unit' did not induce any measurable shifts in wheat acreage.

Since supplementary quotas were in effect only two years of the twelve under analysis, inclusion of this variable as an entity was avoided and instead the supplementary quota levels (converted to a specified acreage base) were added to the corresponding specified acreage quota levels. When included with price (Equation #5) this variable proved less significant than the specified acreage quota, alone. The formation of another quota variable through the summation of all corresponding quotas (supplementary, unit, and specified acreage) provided almost identical results (Equation #6). This latter specification adds support to the hypotheses that unit quotas were insignificant in affecting wheat seeding decisions.

It furthermore indicates that supplementary quotas did not have a significant effect on wheat acreage during the period analysed. One explanation for this set of findings is that supplementary quotas were implemented infrequently and producers treated them as windfall gains and did not adjust acreages in response to them.

The above results therefore provide a rationale to exclude unit and supplementary quotas from the analysis as specific factors inducing wheat acreage response.

The Inclusion of Other Price Variables

In the development of the conceptual model the returns from sales of other crops had been hypothesized as possible factors which could have had an influence on wheat acreage. These factors were specifically incorporated into the regression model as the price of oats, the price of barley, and the price of flaxseed.

A Priori, it was hypothesized that the price of barley would have had more influence on wheat acreage seeding decisions than would oats price or flaxseed price. It was anticipated that as the price for barley rose, less acreage would be alloted to wheat production and more acreage seeded to barley. If any influence was exerted on wheat acreage by either flaxseed price or oats price the effects would be analagous to those for barley.

Each of the above three variables was individually included in the regression along with price of wheat and the specified acreage quota. The results in Table 4-4 show that no statistical significance can be attributed to any of the three price variables. This indicates that neither the price of oats, barley or flaxseed had any significant influences on the acreage seeded to wheat during the 1958 to 1969 period. The results tend to disprove the hypothesis that barley price influences

Table 4-4

Results of Estimation When Prices of Oats, Barley and Flaxseed are Included

Equation Number	Constant Term	Regression Coefficients: Price of Wheat (T-2)	Specified Quota Level (T-1)	Price of Oats (T-2)	Price of Barley (T-2)	Price of Flax (T-1)	R^2	Durbin Watson	Standard Error of Estimates
1	4.47	(3.57) 10.48***	(1.94) 0.56*				.84	2.33	1.16
2	3.01	(2.12) 8.14*	(2.14) 0.65*	(0.96) 0.069_x			.86	2.38	1.16
3	4.48	(2.11) 11.41*	(1.83) 0.57		(0.211) -0.015		.84	2.34	1.22
4	6.16	(3.41) 10.58***	(1.82) .548			(0.38) -0.57	.84	2.30	1.21
Means:		1.80	5.36	74.9	113.5	3.22			
Units:		Dollars[1]	Bushels per Specified Acre	Cents[1]	Cents[1]	Dollars[1]			

(1) Per bushel

"x" - denotes a sign opposite to *a priori* hypothesis.

wheat acreage[1] and also contradict Schmitz's findings on the influence of flaxseed prices on wheat acreage.[2]

Recursivity and Trend in the Wheat Acreage Response System

The next section of analysis incorporated a two crop-year lag in the specified acreage quota variable in order to provide direct correspondence to the analysis conducted by Pearson. The basis for this form of specification rests on the possible recursivity of the wheat acreage response system. It was hypothesized that the quota variable lagged two crop-years would, if significant, possess a positive coefficient indicating increases in wheat acreage in response to historic increases in quota levels. Due to the relative proximity of quotas lagged one crop-year (in a time dimension context) it was anticipated that the 'T-2' quota variable would be less significant than the corresponding 'T-1' quota variable.

A trend variable was also included at this stage for the first time in the analysis and was designed to account for increases in acreage stemming from factors such as the producers' ability to cultivate larger acreages through advanced technology. A positive sign on the trend

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[1] It was noted that barley prices and wheat prices were highly correlated. Since the insignificance of barley price could have been a result of multicollinearity, a wheat price-barley price ratio was formed and tested. The results in Table 4-8 indicate a complete failure on the part of this ratio to explain any variations in wheat acreage. As a result barley prices were excluded from further detailed analysis and it was concluded that the price of barley was not a significant factor to producers when making their wheat acreage seeding decisions.

[2] Schmitz, op. cit., p. 83.

Table 4-5

Results of Estimation When Quotas Lagged Two Years and Trend are Included

Equation Number	Constant Term	Regression Coefficients: Price of Wheat (T-2)	Specified Quota Level (T-1)	Specified Quota Level (T-2)	Time Trend	Price of Barley (T-2)	Actual Unit Quota (T-1)	R^2	Durbin Watson	Standard Error of Estimate
1	9.89	(1.40) 5.69^{o}	(2.03) .536*	(1.58) .609^{o}				.88	2.18	1.06
2	10.13	(1.29) 7.30	(1.97) 0.568*	(1.54) 0.634^{o}		(0.438) -0.030		.88	2.17	1.12
3	14.12	(1.45) 5.99^{o}	(1.67) 0.465^{o}	(1.45) 0.569^{o}			(0.89) -4.72$_{x}$	.89	2.06	1.08
4	17.46		(3.77) 0.812***	(1.73) .534^{o}	(2.25) .250*			.91	2.42	.93
Means:		1.80	5.36	5.44	6.5	113.5	0.88			
Units:		Dollars[1]	Bushels[2]	Bushels[2]	--	Cents[1]	Bushels[2]			

(1) Per bushel

(2) Per specified acre

"x" - denotes a sign opposite to *a priori* hypothesis.

coefficient was hypothesized.

The resulting regressions (Table 4-5)[1] do carry the correct positive signs on the 'T-2' quota variable and the trend variable. However inclusion of the 'T-2' quota variable lowers the significance of price of wheat (Equations #1 to #3).

An interesting result is presented by regressing wheat acreage on quotas lagged one and two years and trend. All three variables turn out significant and an R^2 of .91 results (Equation #4). Though this Equation does not correspond to the conceptual model it does lend support to the hypothesis that several variables which are important in influencing wheat acreage are channeled in part through quota levels.

Establishing the Validity of the 'Open' Quota Level Calculation

With the analysis thus far having shown that the specified acreage quota does in fact 'belong' in a model explaining wheat acreage fluctuations it was considered necessary to examine the ramifications of having calculated a quota level of 5.96 bushels for the year of 'open' quotas at April 30th.[2] The sensitivity of this figure was tested by arbitrarily choosing levels of one bushel per specified acre above and below the calculated level and running several regressions using these new values. If the 5.96 level were in fact an appropriate specification

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[1] The price of barley was included in one regression in this Table as a further test to ascertain the validity of omitting it from the final model. A similar treatment was given to the unit quota in Table 4.5. Both sets of results show the insignificance of the variables as was noted earlier.

[2] See Chapter III; the section on Data Requirements, Availability and Problems.

Table 4-6

Results of Including the 'Open' Quota at Various Levels

Equation Number	'Open' Quota Level at:	Constant Term	Regression Coefficients: Average Specified Acreage Quota Level (T-1)	Regression Coefficients: Average Specified Acreage Quota Level (T-2)	Time Trend	R^2	Durbin Watson	Standard Error of Estimate
1	6.96	17.40	(2.49) 0.648**	(3.53) 0.983***		.82	1.77	1.23
2	5.96	17.14	(2.74) 0.695**	(3.73) 1.01***		.85	1.81	1.12
3	4.96	17.23	(2.94) 0.740**	(3.61) 0.973***		.85	1.69	1.13
4	6.96	17.59	(3.54) 0.761***	(1.73) 0.514^{o}	(2.41) 0.272**	.898	2.33	0.99
5	5.96	17.46	(3.77) 0.812***	(1.74) 0.535^{o}	(2.26) 0.250*	.909	2.42	0.93
6	4.96	17.57	(3.78) 0.831***	(1.68) 0.530^{o}	(2.07) 0.239^{o}	.903	2.30	0.97
Means:	--	--	5.36	5.44	6.5			
Units:	Bushels[1]	--	Bushels[1]	Bushels[1]	--			

(1) Per specified acre

the regressions using that level should possess the most explanatory power.

The results in Table 4-6 indicate that though the 5.96 level did provide a better (or at least equal R^2) to the other two levels, there was very little variation in explanatory power indicating an insensitivity to minor fluctuations in the calculated level. (The lower T-values on the 6.96 check indicate that this level has lowered the significance of quotas--i.e. the value is too high).

These results provided statistical validity for the continued inclusion of the 'open' quota at a 5.96 level throughout the analysis.

Average Specified Acreage Quota Versus Maximum Specified Acreage Quota

A test was conducted to discover whether producers, in aggregate, were in fact responding to the average specified acreage quota or were responding to some other variable. A variable of '<u>maximum</u> specified acreage quota levels at April 30th' was used as one possible alternative. If this new 'maximum quota' turned out more significant than the previous quota variable this would indicate that producers had a good knowledge of wheat quotas in other parts of the prairies, and due to the Canadian Wheat Board policy of quota equalization at crop year end, anticipated increases in their own quotas to these 'maximum' levels and based seeding decisions on these expectations.

Higher significance for the 'average' quota variable would indicate poor knowledge of quota levels in other sections of the prairies by producers or an unwillingness to base expectations on good knowledge.

Table 4-7

Comparison of 'Average' and 'Maximum' Specified Acreage Quota Levels

Equation Number	Constant Term	Regression Coefficients: Average Specified Acreage Quota Level (T-1)	Maximum Specified Acreage Quota Level (T-1)	Dummy Unit Quota (T-1)	Price of Wheat (T-2)	Time Trend	R^2	Durbin Watson	Standard Error of Estimate
1	4.47	(1.94) 0.555*			(3.57) 10.48***		.84	2.33	1.15
2	0.93		(1.85) 0.375*		(5.37) 12.67***		.84	2.31	1.17
3	5.85	(1.51) 0.636^{o}		(0.275) 0.359	(1.91) 9.42		.85	2.35	1.22
4	0.63		(1.38) 0.358	(0.114) -0.129	(3.88) 12.92***		.84	2.32	1.24
5	15.59	(2.51) 0.93**			(0.32) 2.04	(1.46) 0.31^{o}	.88	2.45	1.08
6	4.11		(1.85) 0.442*		(2.13) 10.23*	(0.59) 0.12	.85	2.27	1.22
Means:		5.36	6.83	--	1.80	6.5			
Units:		Bushels[1]	Bushels[1]	--	Dollars[2]	--			

(1) Per specified acre
(2) Per bushel

Table 4-8

Results of Estimation When Wheat and Barley Prices are Incorporated as a Ratio

		Regression Coefficients							
Equation Number	Constant Term	Average Specified Acreage Quota Level (T-1)	Farm Wheat Stocks (T-1)	Time Trend	Exports of Wheat (R-1)	Wheat Barley Price Ratio[1] (T-2)	R^2	Durbin Watson	Standard Error of Estimate
1	33.63					(0.38) -4.57	.014	.51	2.76
2	16.13	(1.93) 0.842*			(1.45) $.009^{o}$	(0.18) 1.38	.71	1.13	1.68
3	15.11	(3.11) 0.860**		(3.58) 0.349***	(1.07) .004	(0.34) 1.65	.897	2.47	1.07
4	8.88	(1.83) 1.24^{o}	(0.787) 0.006		(0.68) .005	(0.108) 4.13	.73	1.69	1.72
5	4.53	(4.26) 1.62***	(1.52) $.010^{o}$			(0.80) 6.22	.71	1.93	1.66
6	17.39	(2.75) 0.925**	(0.52) -.003	(3.22) 0.428**		(0.25) 1.41	.88	2.60	1.13
7	14.50	(3.87) 1.28***				(0.39) 3.16	.63	0.95	1.78

(1) The mean for this variable was 1.59 dollars/cents. All other means and units have been reported in earlier tables.

The reaction to variations in quotas would therefore be through the reaction of individual producers to their own quota level--or in aggregate--to the 'average' specified acreage quota level in the prairies.

In all three comparisons of the 'average' and 'maximum' quota variables (using a variety of other regressors in the pairwise comparisons) the 'average' variable had a higher T-value. (Table 4-7). However, the significance of the 'maximum' variable shows that some half-way point exists between the two theoretical possibilities outlined. That is, while most farmers probably based seeding decisions on their own quota levels, some producers did in effect base their decisions on levels which were prevailing in other areas of the prairies.

Due to the better 'fits' obtained with the 'average' variable, any further consideration of the 'maximum' variable was omitted in subsequent sections of the analysis.

Adaptive Expectation Models

The analysis thus far was based on the traditional expectations model which assumes that a producer bases his expectations of price on the latest actual price available to him prior to his production decision. Stated mathematically this is:

$$P_t^* = P_{t-1}$$

In the simple model:

$$Y_t = \alpha + \beta P_t^* + U_t \qquad \text{(Equation(1)}$$

where Y_t is the acreage seeded to wheat,

P_t^* is the expected wheat price, and

U_t is the disturbance ter

Table 4-9

Results of Adaptive Expectations Models

Equation Number	Specification	Constant Term	Regression Coefficients: Average Specified Acreage Quota Level (T-1)	Regression Coefficients: Wheat Acreage (T-1)	Regression Coefficients: Price of Wheat (T-2)	R^2	Durbin Watson	Standard Error of Estimate
1	Quota Expectations Linear	8.81	(4.59) 0.883***	(4.65) 0.492***		.889	2.99	0.97
2	Price Expectations Linear	0.55	(0.[illegible])	(0.112) 0.034	(2.45) 13.82**	.78	1.99	1.38
3	Quota Expectations Log	0.59	(5.12) 0.171***	(5.47) 0.502***		.91	3.13	0.014
4	Price Expectations Log	1.06		(0.348) 0.100	(2.27) 0.869**	.78	1.86	0.023
5	Combined Models Linear	9.04	(2.83) .898**	(1.81)° 0.507	(0.061) -.401x	.89	3.01	1.03
Means:		5.36	26.1	1.80				
Units:		Bushels per spec. acre	Millions of acres	Dollars per bu.				

"x" - denotes sign opposite to *a priori* hypothesis.

U_t is the disturbance term[1]

The adaptive expectations model assumes that

$$P_t^* - P_{t-1}^* = \gamma \; (P_t - P_{t-1}^*) \qquad (2)$$

$$0 < \gamma \leqslant 1$$

or that expectations are varied each decision period by some fraction (γ) of the difference between observed price and what the price was expected to be in the previous period.[2] γ is the coefficient of adjustment. Combination of (1) and (2) produces an equation which contains only observable values and is therefore estimable:

Rewrite (2) as

$$P_t^* - \lambda \; P_{t-1}^* = \gamma \; P_t \qquad (3)$$

where

$$\lambda = 1 - \gamma$$

Define a lagged operator L so that (3) becomes

$$(1 - \lambda L) \; P_t^* = \gamma \; P_t \qquad (4)$$

or

$$P_t^* = (\gamma / 1 - \lambda L) P_t \qquad (5)$$

Substituting (5) into (1) gives

$$Y_t = \alpha + (\beta\gamma / 1 - \lambda L) \; P_t + U_t \qquad (6)$$

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[1] It is important to note that whereas the one period lag has been the generally accepted lag structure--a two crop-year lag for the price variable is in fact a more appropriate specification when concerned with wheat acreage response.

[2] Johnston, op. cit., pp. 301-302.

Multiplying by (1 - L) and rearranging

$$Y_t = \alpha(1-\lambda) + \beta(1-\lambda)P_t + \lambda Y_{t-1} + (U_t - \lambda U_{t-1}) \qquad (7)$$

(7) is in estimable form--but contains a lagged endogenous variable. The presence of auto-correlated disturbance terms in such a model would produce biased and inconsistant results.[1] In such cases the Durbin-Watson statistic is biased towards two and may lead to the conclusion of no autocorrelation when in fact it may be present.[2]

A similar system was developed for producers' adaptive expectations to quota levels:

$$A_t = a + b\, Q^*_t + U_t \qquad (1)$$

where Q^*_t is the expected quota level and At is wheat acreage seeded.

$$Q^*_t - Q^*_{t-1} = \beta\,(Q_{t-1} - Q^*_{t-1}) \qquad (2)$$

Combining (1) and (2)

$$A_t = a\beta + (1-\beta)A_{t-1} + (b\beta)\, Q_{t-1} + (U_t - \lambda\, U_{t-1}) \qquad (3)$$

Both the quota expectations and price expectations models were estimated in linear and log form. The results are presented in Table 4-9. In the price expectations model, the lagged wheat acreage coefficient was not significant (Equations #2 and 4).[3] The Durbin-Watson statistic was close to two and observation of the actual residuals led to a

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[1]The disturbance term in part explains the dependent variable. If the disturbance terms are serially correlated this presents a case where one of the regressors (the lagged endogenous variable) is correlated to the disturbance term. This constitutes a failure of one of the basic assumptions of least squares estimation.

[2]Johnston, op. cit., pp. 312-312.

[3]This compares favourably with Schmitz's findings using an adaptive expectations model (See Chapter II p. 15).

conclusion of no autocorrelation. The size of the price coefficient was consistent with previous traditional linear specifications.

In the quota expectations model both variables turned out significant but negative autocorrelation seemed to be present (Equations #1 and #3). This led to the expectation of bias in the regression coefficients.

When both expectation models were combined in linear form a reversal of sign occurred on the price variable--probably due to multicollinearity between lagged wheat acreage and price (Equation #5).

Due to the presence of both these statistical problems (multicollinearity and negative autocorrelation) the adaptive expectations hypothesis was dropped in further specifications (which in essence entailed the removal of lagged wheat acreage from the set of regressors).

Consolidation of Results

Variables which have been shown to be significant factors in influencing wheat acreage during the 1958 to 1969 period include the price of wheat, wheat export levels, specified acreage quota levels and farm wheat stocks. Variables which do not appear to have significant effects on wheat acreage include the returns (prices) from flaxseed, barley and oats as well as the unit and supplementary quotas. These results support the hypotheses that the price of wheat, exports, farm wheat stocks, and quotas groupings are important factors in influencing wheat acreage. The insignificance of the barley, flax and oats prices indicates that the 'returns from other crops' are not important in farmers' wheat acreage seeding decisions.

Table 4-10

Consolidation of Estimation Results

		Regression Coefficients							
Equation Number	Constant Term	Price of Wheat (T-2)	Exports of Wheat (T-1)	Average Specified Acreage Quota Level (T-1)	Farm Wheat Stocks (T-1)	Stocks Quotas Ratio (T-1)	R^2	Durbin Watson	Standard Error of Estimate
		(5.24)	(3.09)						
1	2.96	10.97***	.009**				.89	1.63	.95
		(3.57)		(1.94)					
2	4.47	10.48***		0.56*			.84	2.33	1.15
		(5.51)	(3.23)		(1.46)				
3	4.55	10.87***	.009**		-0.004[o]		.915	1.65	.904
		(5.41)	(2.78)			(1.74)			
4	5.37	10.39***	.008**			-0.011[o]	.922	1.62	.866
Means:		1.80	386.2	5.36	337.4	73.8			
Units:		Dollars per bushel	Millions of bushels	Bushels[1] per spec. acre	Millions[2] of bushels	(2)/(1)			

Several of the regressions including the significant variables have been amalgamated into one table (Table 4-10) including the 'best' specification.

Regressing wheat acreage on price of wheat and export levels revealed the high significance of these variables (Equation #1). Using specified acreage quota levels along with price indicated that the quota variable should be a part of the final specification (Equation #2).

A fairly satisfactory specification seemed to be the regression of wheat acreage on price, exports, and farm wheat stocks (Equation #3). A high level of explanatory power, a Durbin-Watson statistic close to two and a low standard error were all attributes of this Equation. However, inclusion of the specified acreage quota as a discrete variable in this specification created a severe multicollinearity problem.[1]

In the development of the conceptual model, it had been recognized that farm stocks and quota levels were linked in a circular pattern.[2] This recognition allowed an additional hypothesis to be formulated--that it is the levels of stocks relative to the quota advancement which producers take into consideration when making wheat seeding decisions. Thus the implementation of stocks and quotas as a ratio was a possible method of overcoming the statistical estimation problem. This final specification, did provide the best statistical 'fit' (Equation #4 in Table 4-10).

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[1]See Table 4-2.

[2]See Chapter 3 - Section on 'Interrelationship Within the Wheat Acreage Response System', pp. 32.

There appear to be no statistical problems present in this specification. The T-value on 'stocks - quotas' variable is higher than the T-value on just the 'stocks' variable in Equation #3 indicating an improvement over Equation #3 (as well as having a higher R^2 and a lower standard error).

In reality this specification may be masking some of the effects of quotas but at least all four variables which have been shown to be statistically significant when used singly, are amalgamated into one regression with no apparent statistical problems.[1]

Interpretation of Final Specification

The final specification of a statistically significant model explaining variations in aggregate wheat acreage during the 1958 to 1969 period was:

$$Aw = 5.37 + 10.39\ Pw_{(T-2)} + 0.008Ex_{(t-1)} - 0.011\ (Sw_{(t-1)}/Qs_{(t-1)})^2$$

where:

Aw = Actual wheat acreage (including durum) in the Prairie Provinces (in millions of acres).

$Pw_{(t-2)}$ = Final realized price of No. 1 Northern Wheat, basis Thunder Bay, lagged 2 crop years (in dollars).

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[1]The final specification was tested for heteroscedasticity using Goldfield and Quandt's method (Johnston - Pages 218-219) of grouping the observations into lower and upper ranges and then conducting an F-test on the ratio of the sum of squared residuals in each range. Though the test showed no heteroscedasticity present, the test was not very powerful due to the very limited number of degrees of freedom available.

[2]The Corresponding elasticities were 0.71, 0.12 and -0.03 for price, exports and the stocks-quotas ratio respectively.

$Ex_{(t-1)}$ = Exports of Canadian wheat and wheat flour, lagged 1 crop year (in millions of bushels).

$Sw_{(t-1)}$ = Farm wheat inventory levels at April 30th (in millions of bushels).

$Qs_{(t-1)}$ = The average specified acreage quota level at April 30th (in bushels per specified acre).

The first two coefficients may be interpreted as follows: With a constant term of 5.37 (million acres) a 10 cent increase in the price of wheat increases aggregate wheat acreage by 1.04 million acres;[1] and a 100 million bushel increase in wheat exports increases wheat acreage by .8 million acres. Interpretation of the last coefficient is more difficult. Stated in the simplest manner; an increase of 1 unit in the stocks to quotas ratio decreases wheat acreage by .011 million acres (keeping in mind that farm stocks are in 'million of bushels' and quotas are in 'bushels per specified acre'). Further interpretation is best accomplished by means of charting out changes in wheat acreage under various combinations of changes in stocks and quotas. (Table 4-11). Table 4-11A shows the changes in wheat acreage occurring from a 100 million bushel increase in farm wheat stocks with quotas kept constant at various levels. For example, keeping quotas constant at a level of three bushels per specified acre decreases wheat acreage by .367 million acres when farm stocks are increased by 100 million bushels.

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[1]There existed a high positive correlation between the price of wheat variable and the time trend. As a result the estimated wheat price coefficient may be higher than the 'true' unobservable value, due to the price of wheat variable picking up some wheat acreage trends. However the price coefficient compares favourably to Anim-Appiah's results when time was in fact included. In addition the constancy of the price coefficient throughout the analysis suggests that the 'true' value is close to estimated coefficient of 10.39.

Table 4-11A

Changes in Wheat Acreage Resulting From

Changes in Farm Wheat Stocks

Quotas at:	Change in Wheat Acreage Resulting From a 100 Million Bushel Increase in Farm Wheat Stocks
3 bushels	-.367 million acres
4 bushels	-.275 million acres
5 bushels	-.220 million acres
6 bushels	-.183 million acres

Table 4-11B

Changes in Wheat Acreage[a] Resulting From

Specific Changes in the Specified Acreage Quota Level

	Change in Specified Acreage Quota Level:		
Farm Wheat Stocks at	3.0 to 4.0 bu.	4.0 to 5.0 bu.	5.0 to 6.0 bu.
200 million bu.	.183	.110	.073
300 million bu.	.275	.165	.110
400 million bu.	.367	.220	.147
500 million bu.	.458	.275	.183
600 million bu.	.550	.330	.220

[a] in millions of acres

Table 4-11B shows the change in wheat acreage associated with specific 1 bushel per specified acre increases in quotas with stocks held constant at various levels. With stocks at 500 million bushels a change in the quota level from 3 to 4 bushels increases wheat acreage by .458 million acres. As quotas get larger, the increases in wheat acreage resulting from a 1 bushel increase get considerably smaller (reading across the table). As stocks get larger, the changes in acreage due to quota increases get larger (reading down the table). These results are consistent with hypothesized directions of change in wheat acreage from changes in quotas and stocks.

Consideration of simultaneous changes in stocks and quotas is more difficult to present in table form. However the regression coefficient (-.011) can be used to calculate any specific combination of changes. As one possible example an increase of stocks from 500 to 600 million bushels and a reduction in the specified acreage quota level from 6 to 3 bushels would decrease wheat acreage by 1.28 million acres.

Testing the Predictive Power of the Model

Due to the implementation of the LIFT program in 1970 and the changeover to the assigned acreage quota system in that year it was impossible to use the statistical model for predicting the actual wheat acreage for 1970 or more recent years. However the model was used to predict what seeded wheat acreage would have been in 1970 had the LIFT program not been implemented. A value of 21.24 million acres was predicted for the 1970-71 crop-year and since the actual wheat acreage was 12 million, there was an apparent 9.24 million acre reduction in wheat acreage due to the LIFT program. This compares favourably with the 10 million acre reduction figure obtained by Craddock and Sahi through linear programming techniques.[1]

To test whether the inclusion of the stocks to quotas ratio was in fact useful for predictive purposes, a prediction was made for the 1970-71 crop-year using a model with only price and exports as regressors. This model predicted that wheat acreage would have been 24.71 million acres without a policy of the LIFT type. The difference between the prediction and the actual value (12.71 million acres) is taken as another estimate of the impact of LIFT (using the model without the stocks to quotas variables).

Thus the model including the stocks to quotas ratio predicted within 7.6% of Craddock's and Sahi's acreage reduction figure of 10 million acres while the model without this ratio predicted a value that was out by 27.1%.

The model was also tested for the year prior to the period of analysis and predicted a wheat acreage figure of 22.86 million acres for the 1957-58 crop-year. The model excluding the stocks to quotas ratio predicted an almost identical 22.98 million. The actual wheat acreage in the 1957-58 crop-year was 20.9 million so in effect both models had an approximate error of 10%.

The almost identical predictions do not invalidate the inclusion of stocks and quotas in a model of wheat acreage response. In fact these results should have been anticipated due to the limited experience

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[1] W. J. Craddock and R. K. Sahi, "Effect of LIFT on Land Use", <u>Canadian Farm Economics</u>, Vol. 6, No. 5 (December 1971).

producers had had with restrictive quotas by 1957. (Only starting in 1952 did quotas impose crop-year end marketing limitations. In addition the 1952 to 1958 period saw higher wheat marketings than in any previous period but due to high production, quotas were restrictive and farm stocks increased). Due to these unusual circumstances, there might have been no response to quotas by 1957 because producers thought them transitory.

In general, the model seems to perform adequately for predictive purposes, but can not be directly applied to the present time period due to the modifications in the quota system.

SECTION 2 - REGIONAL PRODUCTIVITY ANALYSIS

The first section of the analysis showed that the specified acreage quota was in fact an important decision variable for producers of wheat. The second section of analysis was designed to discover whether there existed any variations in these responses to quota levels on the basis of productivity factors. To accommodate this stage, the prairie provinces were sub-divided into five 'Commercial Farming Regions', (as defined in the 1961 Census of Canada) in order to provide a simple proxy for productivity. These were:

1. a wheat region
2. an area of grains other than wheat
3. intensive cropping areas
4. mixed farming

5. 'Cattle' regions[1]

A sample of twenty delivery points was selected randomly from each region and an average wheat acreage per farm was calculated for use as the dependent variable. Data on a delivery point basis was limited to a nine year period from 1961 to 1969.

Due to the limited years available for analysis and since primary concern was in the response to quotas, only 2 dependent variables were used--specified acreage quota levels and time trend. Trend was used to pick up a multitude of effects (including a percentage of the price effect) in one non-quota variable. This was done in an attempt to conserve the extremely few degrees of freedom available.[2]

A priori, it was hypothesized that producers' in the various commercial farming regions reacted differently in terms of wheat acreage when faced with identical quota level situations. Quotas should have greatest effects on wheat acreage in the 'crops region' that does not specialize in wheat (i.e. Region 2). Wheat region farmers would appear to have summerfallow as their only alternative if quotas were low--since cropping patterns are generally quite firm in this region due to inadequate moisture. Therefore quotas would have small impact in Region 1. Regions 3, 4, and 5; the intensive cropping, mixed farming and cattle

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[1]The 'cattle' region was a consolidation of the 'Beef' and 'Dairy' areas of the Census.

[2]Due to the omission of important variables, bias could be interjected into the quota coefficients. In order to decrease this bias, trend was included to pick up some of the effects of the omitted variables. It was assumed that any bias still present would be dispersed equally in the quota coefficients.

regions respectively, should have less response than Regions 1 and 2 due to the lesser importance of wheat in these three regions.

The results of the analysis are presented in Table 4-12. Quotas turned out to be significant at the 5% level in the "Other Grains" and "Intensive Crops" regions; at the 10% level in the "Wheat" region and at the 20% level in the "Mixed Farming" regions. They were not significant in the "Cattle" region. In general these results were consistent with expectations. (An unanticipated result was the high significance of quotas in the 'intensive crops' region. This seems to indicate that wheat is a very real alternative to the producers in this region, an observation that coincides with the high substitution possibilities for crops in the region).

Initial observation of the results revealed differences in the sizes of the quota coefficients in various regions, (the range was from 11.21 to 0.65). The ranking of size was as hypothesized with only minor deviations. To test whether these apparent differences were in fact significant a T-test of pairwise comparisons was performed on the coefficients.[1] The results of the test as shown in Table 4-13, do in fact indicate significant differences in the sizes of the coefficients in:

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[1] Other statistical tests for the comparison of regression coefficients are available (See Foote). These tests require that the variances of the coefficients be equal. Since in this case it is unknown whether variances are equal, but sample sizes are equal in each regression the appropriate test is

$$t_{(n-k-1)} = \frac{\hat{\beta}_1 - \hat{\beta}_2}{\frac{\sigma_1^2 + \sigma_2^2}{n}}$$

(See Snedecor and Corhran, p. 115).

Table 4-12

Results of Estimating the Effects of Quotas in Various Commercial Farming Regions

Commercial Farming Region	Constant Term	Regression Coefficients: Average[1] Specified Acreage Quota Level (T-1)	Regression Coefficients: Time Trend	R^2	Durbin Watson	Means of Dependent Variable[2]
1 Wheat	131.85	(2.46) 11.21*	(3.46) 9.91**	.72	1.37	246.3
2 Other Grains	84.22	(3.03) 6.67**	(4.97) 6.88***	.83	2.09	157.3
3 Intensive Crops	61.29	(2.59) 7.88**	(2.00) 3.82^{o}	.61	1.44	126.1
4 Mixed Farming	65.06	(1.65) 2.29^{o}	(3.87) 3.36**	.73	2.42	95.1
5 Cattle	16.96	(1.29) 0.65	(4.6) 1.46***	.78	2.72	28.0

(1) The mean was 5.79 bushels per specified acre

(2) Average wheat acreage per farm (in the sample)

Table 4-13

Paired T-test Comparison of Quota Coefficients

Regions	Calculated T-value[a]
1. Versus 2.	0.83
1. Versus 3.	0.53
1. Versus 4.	1.88^{o}
1. Versus 5.	2.30*
2. Versus 3.	0.32
2. Versus 4.	1.68^{o}
2. Versus 5.	2.67**
3. Versus 4.	1.62^{o}
3. Versus 5.	2.35*
4. Versus 5.	1.12

a $$t = \frac{\hat{\beta}_i - \hat{\beta}_j}{S.E.\ (\hat{\beta}_i - \hat{\beta}_j)}$$

A. Region 1 versus Regions 4 and 5

B. Region 2 versus Regions 4 and 5

C. Region 3 versus Regions 4 and 5

These differences indicate that there were significant variations in response to specified acreage quotas on a productivity basis during the 1961 to 1969 period.

The results of this analysis of quota response in different farming regions classified according to a productivity criterion provide ample indication that the issue of productivity merits further analysis in respect to quota policy. The case for further detailed exploration of that aspect alone is strongly justified by the findings obtained in this study.

SECTION 3 - A CROSS SECTION AND TIME SERIES APPROACH TO THE MULTICOLLINEARITY PROBLEM

Though a fairly satisfactory model for explaining aggregate wheat acreage had been developed in Section One of the analysis, there existed the possibility that some of the effects of quotas were being masked because of multicollinearity. One of the methods around the multicollinearity problem is through the application of cross-sectional analysis for the extraneous estimation of one of the regression coefficients. This is followed by the inclusion of the auxilliary information in the time series regression.

Ideally an extraneous estimate of the quota coefficient should have been made since it is this variable that lost significance wher when included in the same regression as exports. However, cross-sectional data on quotas was not available. Alternatively, it was felt that if the 'farm stocks' coefficient could be estimated, some additional information would be provided for improving the time series regression.

The cross-section model was specified in the following manner:

Aw = F(Sw, Fsize, Hent, Bent)

Where:

Aw = Farm wheat acreage

Sw = Farm wheat stocks

Fsize = Farm size - in terms of number of acres cultivated

Hent = Size of hog enterprise in terms of number of hogs on farm

Bent = Size of beef enterprise in terms of number of cattle on farm

The wheat acreage and farm wheat stocks variables correspond to the basic conceptual model. The hog and beef enterprises in this case are directly related to 'returns from alternate production activities' in the model.[1] The farm size variable was included to account for variations in wheat acreage between individual farms that were of various sizes.

Some variables were omitted from this specification because of limited variations across producers (such as price of wheat) while others were omitted due to inavailability of data (such as quota levels).

It was hypothesized that the stocks, hog, and beef variables, would carry negative coefficients and the farm size coefficient would be

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[1]See Chapter III, p. 28.

positive.

Single equation least squares yielded the following results:

$$Aw = 7.27 + \underset{(7.36)}{.003}\ Sw + \underset{(46.6)}{.207}F_{size} - \underset{(7.63)}{.245}\ B_{ent} - \underset{(0.28)}{.002}\ H_{ent}$$

$$R^2 = .61 \quad D.W = 1.75$$

The size of the hog enterprise turned out to be insignificant while the farm size and the size of beef enterprise variables were significant at the 1% level of confidence. The wheat stocks coefficient turned out positive--contrary to expectations--and thereby proving inappropriate for inclusion in the time series regression. A possible reason for the positive sign could be due to stocks picking up some farm size characteristic in the regression. That is--large wheat farmers would have relatively large wheat stocks and would likely grow large acreage of wheat in comparison to small wheat farmers.

This reversal of sign necessitated the use of first difference rather than 'level' data. However matched pairs of observations on the required variables were available only for the 1970 to 1971 changes. This aspect was undesirable for several reasons:

1. It is outside the 1958 to 1969 period of time series analysis, and
2. It involves the change back to higher wheat acreages after the LIFT program of 1970.

Since changes in wheat acreage were being analysed the previous cross-section model was respecified in the following manner:

Aw = F(Sw, Ca, Smf)

Where:

Aw = Change in wheat acreage from 1970 to 1971

Sw = Change in farm wheat stocks from 1970 to 1971

Ca = Change in cultivated acreage from 1970 to 1971

Smf = Change in Summerfallow from 1970 to 1971

It was hypothesized that the stocks and summerfallow coefficients would be negative while the cultivated acreage coefficient (again used as a size of farm variable) was expected to be positive.

Single equation least squares on the cross-sectional first difference data yielded the following results:

$$Aw = 7.70 - \underset{(3.54)}{.010Sw} + \underset{(3.74)}{.127Ca} - \underset{(5.26)}{.294mf}$$

$$R^2 = .04 \quad D.W. = 1.98$$

This time all signs were as hypothesized and all coefficients were significant at the 1% level of confidence. The low R^2 indicates that in fact very little of the change in wheat from 1970 to 1971 acreage is explained by the model. (This is probably due to the years involved and the shift back to 'normal' acreages after the LIFT year). Though extremely poor in explanatory power this specification did in fact provide a statistically significant extraneous estimate for the stocks coefficient. This estimate for the stocks coefficient was included in the aggregate time series regression as known with certainty.[1] Two alternate specifications

[1]It should be noted that when the inclusion of the estimate is made as known with certainty, the results of the time series analysis become conditional upon the estimates obtained from the cross-section data. Alternate methods are inclusion of interval instead of point estimates or simultaneous estimation of both the cross-section and time series. (See Chetty, 'Pooling of Time Series and Cross Section Data').

were used which stemmed from the first section of analysis:

$$(1)\quad Aw_{(t)} - \hat{b}\, Sw_{(t-1)} = f\,(Pw_{(t-2)}, Ex_{(t-1)}, Q_{spec(t-1)})$$

$$(2)\quad Aw_{(t)} - \hat{b}\,(Sw_{(t-1)}/Q_{spec(t-1)}) = f(Pw_{(t-2)}, Ex_{(t-1)})$$

Where:

$Aw_{(t)}$ = Aggregate wheat acreage for Western Canada (including durum).

$Sw_{(t-1)}$ = Aggregate farm wheat stocks at April 30th.

$Ex_{(t-1)}$ = Exports of wheat and wheat flour lagged one crop year.

$Pw_{(t-2)}$ = Final realized price of No. 1 Northern wheat basis Thunder Bay - lagged 2 crop years.

$Q_{spec(t01)}$ = The average specified acreage quota at April 30th.

$\hat{b}$ = The extraneous estimate of the stocks coefficient.

The results of the analysis are presented in Table 4-14. Equation 1 in the table indicates the return to the problem which existed in Section One of the analysis--the reversal of sign of the quota variable. The attempt to improve the time series regression through extraneous estimation of coefficients did not work due to the reoccurence of the statistical problem of multicollinearity (theoretically the quota coefficient and not the stocks coefficient should have been estimated). Equation Two held some consolation, however, since by employing the extraneous estimate of the stocks coefficient on the stocks to quotas ratio, the size of the 'price' and 'exports' coefficients remained essentially the same as in the final specification of Section One. This lends support to the validity and interpretation of the meaning of these coefficients

Table 4-14

Results of Cross-Section and Time-Series
Estimation of the Model

Equation Number	Wheat Acreage Minus $\hat{b}$ Farm Wheat Stocks (α)	Wheat Acreage Minus $\hat{b}$ Stocks to Quotas Ratio (α)	Regression Coefficients			R^2	Durbin Watson	Standard Error of Estimates
			Price[1] of Wheat (T-2)	Exports of Wheat (T-1)	Average Specified Acreage Quota Levels (T-1)			
1	4.07		(5.42) 13.08***	(3.57) .012**	(1.88) -.516	.906	1.67	.944
2		5.16	(5.84) 10.44***	(3.11) .008**		.906	1.65	.820

(1) Refer to preceeding tables for variable means and units.

and provides some basis for the integration of the wheat acreage responses to these variables in policy formulation.

Essentially the last section of analysis did not improve the explanatory power of the time series regression. It did provide verification on the size of the coefficients for the price and export variables as well as supporting, to some extent, the inclusion of the stocks and quotas variables as a ratio.

CHAPTER V

SUMMARY AND CONCLUSIONS

SUMMARY

Producer delivery quotas constitute an important feature of the Western grains industry. The quota system was originally implemented to regulate producer deliveries of grain to country elevators but, since 1952, quotas have also restricted in all but three years, the total amounts of grain that could be delivered into country elevators. To the Western wheat producer delivery restriction is synonomous with marketing restriction, since wheat has to be commercially marketed through the Canadian Wheat Board (for whom the country elevator companies act as handling and storage agents). Deliveries and to some extent marketings, of barley, oats, rye, flaxseed and rapeseed are also restricted by Wheat Board delivery quota levels.

The effects of the restrictiveness feature of quotas on producers' supply response has been almost totally neglected in economic research, and only recently have studies such as Pearson's[1] and Sahi's[2] started to approach this issue. However, treatment of this restrictive aspect has been minimal. In addition, it has also been recognized that more research

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[1] Pearson, 'Analysis of Quota Policy'.

[2] Sahi, 'Recursive Programming Analysis of Prairie Land Utilization Patterns'.

is necessary on the implications of ignoring land productivity in the quota system. Because productivity has until now not been incorporated in the quota system, it is likely that the restrictive effects of quotas cause production to be distributed inefficiently in the Western grains industry. Thus there existed a need to explore whether there is a basis for further investigation of the impact of incorporating productivity into the quota system to improve production efficiency.

This study was designed primarily to determine whether there has been an impact on grain producers' supply response from the restrictive effects of quotas. It was hypothesized that farmers had responded negatively to the experience of restrictive quotas in previous years in making decisions on acreage to be seeded. A subsidiary objective was to determine the extent of Western grain producers' response to various individual types of quotas, so as to provide information of use in the assessment of past quota policy and the implementation of future quota policy. As a means of ascertaining the need for further research towards the incorporation of productivity into the quota system, another objective was set to guide the analysis; namely to determine whether there is any indication of different responses to quotas in different productivity regions of Western Canada.

In order to reach these primary objectives it was necessary to analyse the effects of other factors such as prices and inventories of grain on supply response.

Since wheat is the most important crop in Western Canada and since it is generally recognized in the grains industry that deliveries of this crop have been subject to the greatest degree of restriction under the quota system, it was selected as the case for study. The analysis was specified so as to reveal the effects of various types and levels of quotas on the acreage of wheat. This entailed the incorporation of quotas into a supply response framework.

These effects, or responses of producers to quotas, were measured in terms of acreage rather than production in order to abstract from stochastic factors affecting yield and because changes in acreage are considered as the best indication of changes in farmers' desired levels of production.

An examination of historic and present quota policy and a review of literature on the subject of acreage response in Western Canada provided the background for undertaking the analysis.

A conceptual model was developed to approximate the context in which wheat acreage seeding decisions have to be made. Five groups of variables were hypothesized to influence wheat acreage. These were:

1. price of wheat
2. returns from other crops
3. exports of wheat
4. farm wheat inventories, and,
5. quotas under which wheat deliveries had to be made.

Most of these groups operate entirely within an institutional framework established by the Canadian Wheat Board and the Federal Government. The one exception is 'returns from other crops' since, though quota regulated, these crops (barley, oats, rye, flaxseed, and rapeseed) can be marketed through channels other than the Wheat Board.

By the use of policy tools such as commercial inventory holdings the factors within the institutional framework can be manipulated to achieve 'desirable' levels of wheat production.

The five groups of factors (price, exports, quotas, farm stocks, and returns from other crops), the institutional sectors plus other components of the Western grain industry which do not influence wheat acreage directly, are all related. Due to the influences of domestic sales of wheat, commercial wheat storage and other such factors, the direct correlations between quotas, exports and farm stocks are broken, with the result that all three (quotas, exports, farm stocks) warrant inclusion in a model of wheat acreage response.

This basic model was designed essentially to facilitate aggregative analysis at the total industry level for Western Canada. However, it rests on theory which serves as a foundation for analysis at a more disaggregate level, as well.

Regression was chosen as the technique for analysis.

Aggregate Analysis

The analysis was divided into three sections. The first section dealt with aggregate wheat acreage response in the prairie provinces during the 1958 to 1969 period. The extension of the analysis beyond this time period was impossible due to lack of data prior to 1957 and the structural change in the quota system in 1970.

Individual variables from within each of the five groups noted above were specified. (The 'quota' grouping consisted specifically of average specified acreage quotas, unit quotas, supplementary quotas, and maximum specified acreage quotas). Beginning with a statistical estimation framework where price was the only explanatory variable, these individually specified variables were added one by one in order to observe the changes in the regression results. The analysis proceeded in this manner in order to note specific instances of the anticipated problem of multicollinearity. Various other modifications in the specifications were made including alternative specifications of variables and alternative specifications of the manner of response (e.g. adaptive expectations).

The results of the aggregative analysis for the prairies indicated that the unit and supplementary quotas did not affect aggregate wheat acreage during the 1958 to 1969 period. Prices of barley, flaxseed and oats also did not appear to have a significant effect. However, the specified acreage quota, the price of wheat, exports of wheat and farm wheat stocks were all statistically significant in influencing aggregate wheat acreage during the period tested.

The final specification, possessing a high level of explanatory power (R^2 = .922) and with no apparent statistical estimation problems was:

$$Aw = 5.37 + 10.39\ Pw_{t-2} + .008\ Ex_{t-1} - .011\ (Sw_{t-1}/Qspec_{t-1})$$

Where:

Aw = Aggregate annual wheat acreage in Western Canada (in millions of acres)

Pw_{t-2} = Final realized price of No. 1 Northern wheat - basis

Thunder Bay - lagged two crop-years (in dollars per bushel)

Ex_{t-1} = Exports of wheat (and wheat flour) lagged one crop-year (in millions of bushels)

Sw_{t-1} = Farm wheat inventories at April 30th (millions of bushels)

$Qspec_{t-1}$ = Average specified acreage quota level, at April 30th (in bushels per specified acre).

This specification lends support to most of the a priori hypotheses regarding the five groups of factors influencing wheat acreage. However, the 'returns from other crops' grouping is apparently not a factor for wheat acreage seeding decisions.

In general the traditional expectations model seemed adequate for explaining aggregate wheat acreage variations while incorporation of adaptive expectations models led to statistical estimation problems.

As a test of the model's forecasting capabilities a hypothetical wheat acreage figure for 1970 was predicted--assuming no policy of the LIFT type. The result of this prediction compared favourably with Craddock's and Sahi's estimated acreage reduction figure of 10 million acres.[1]

Regional Analysis

The second section of analysis attempted to initiate consideration of the productivity basis for variations in response to quota levels. To accommodate this stage of analysis the prairie provinces were divided

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[1]Sahi, op. cit., p. vii.

into five 'Commercial Farming Regions' (per the 1961 Census) in order to devise a simple and yet meaningful proxy for productivity. A nine year period from 1961 to 1969 was analysed using delivery point data. The results indicated that there were significant variations in response to quotas between regions differing in productivity during the period tested.

Cross-Section and Time Series Analysis

The third section of analysis attempted to further improve Section One results through cross-sectional estimation of the farm wheat stocks coefficient using individual producer data. The extraneous estimate was then introduced into the aggregate time-series analysis. The results of this section provided verification of the size of the price and exports coefficients obtained in Section One. Furthermore, the implementation of farm wheat stocks and quotas as a ratio received additional support. However, this section failed to improve the results of the aggregate time series specification of Section One due to the recurrence of the multicollinearity problem.

POLICY IMPLICATIONS OF THE RESULTS

The findings of this thesis have implications for agricultural policy in two distinct respects. Firstly is the issue of how grains' policy might have differed in the past if the effects of specified acreage quotas on wheat production had been recognized and known. Secondly, are the implications of the results for future policy in the Western grains industry.

One hypothetical although important possibility in assessing past policy is that there might have been no need to implement the LIFT program in 1970. It would appear that, given the significance of wheat price, export levels, and stocks and quotas in producers' wheat seeding decisions, discrete manipulation of these factors could have resulted in substantial decreases in wheat acreage without a program of the LIFT variety. As one possible example; decreasing farm wheat price by 20 cents while increasing farm stocks by 100 million bushels and decreasing specified acreage quota levels by one bushel would have theoretically resulted in an additional decrease in wheat acreage of approximately 3.7 million acres (assuming exports remained constant) from 1968 to 1969.[1] Such policy measures could conceivably be used in two consecutive years--with the possible result of approximately a seven million wheat acreage reduction over two years.

Due to the change in the quota system in 1970 the results of this study are not directly applicable to using policy measures for achieving 'desirable' responses in wheat acreage in the future. However, analysis has shown that producer response to quotas is a historical fact. With all six major crops under the specific assigned acreage quota system at present, there exists the possibility that producers respond to all six individual crop quotas. Thus this new quota system could conceivably be utilized for the purposes of having producers grow the

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[1]This decrease was calculated by taking the actual 1969 levels for these variables and hypothetically changing them by the amounts reported above.

types of grain required for future marketings.

However, such policy measures would require:

1. Good forecasts of world demand for grains at least twelve months into the future.

2. A good knowledge of producer response to assigned acreage quota levels.

The initiation of analysis on a productivity basis has indicated that producers do respond differently to quotas in different regions of Western Canada. Extension of the knowledge of this aspect of quotas may reveal the possibility of achieving more efficient regional distributions of crop production through implementation of unequitable quota levels in various regions.

Even if the use of quota policy to secure specific changes in the patterns of production to improve marketing and/or production efficiency is denied for various non-economic reasons, policy makers should at least be aware that quotas have influenced the patterns of grain production in Western Canada. To the extent these past influences continue in the future, they could have the tendency to reduce the efficiency of the Western grains industry and therefore caution should be exercised in the quota regulation of that industry.

SUGGESTIONS FOR FURTHER RESEARCH

The proper use of agricultural policy in Western Canada requires a good knowledge of producer response to the assigned acreage quota system. Further analysis of quotas should thus center around this new system. Any empirical procedures attempted would have to be devised on a cross-section basis due to the limited span of time over which the new system has been in existence. Such analyses would also provide a good opportunity for further exploration of variations in responses by producers in different areas, facing different productivity conditions.

If quotas are to be used as policy instruments for better gearing market supply to market demand conditions, improved forecasts of world demands for Canadian crops are required. Such forecasts must anticipate market requirements at least 12 months into the future (i.e. one production period) and would require simultaneous consideration of world acreages, expected yields, and purchasing capabilities of foreign countries. In order to facilitate the use of quotas for regulating Canadian crop production, some research must be directed towards such improvement of world market information.

Appendix A

The Method Used to Calculate the Average Specified Acreage Quota Levels at April 30

The following information regarding the number of delivery points at each level was available from the Canadian Wheat Board annual reports. The example presented is for April 30, 1969.

April 30 Quota Level	No. of Delivery Points
Initial Quota	60
1 bu./spec. acre	202
2 bu./spec. acre	352
3 bu./spec. acre	538
4 bu./spec. acre	664
Closed	11
TOTAL	1,827

To obtain the required data each quota level was weighted by the number of delivery points at that level:

$(60 \cdot 0 + 202 \cdot 1 + 352 \cdot 2 + 538 \cdot 3 + 664 \cdot 4 + 11 \cdot 0) \div 1827 = 2.83$ bushels per specified acre. The average specified acreage quota levels for other years were calculated in this same manner.

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