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CANADIAN DEMAND FOR FARM MACHINERY AND RELATED INPUTS

by

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ABSTRACT

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by ROBERT F.J. ROMAIN

MAJOR ADVISOR: DR. DARYL F. KRAFT

Resources demanded by the agricultural sector have been investigated for a number of countries in the past twenty years. The major studies for agricultural durable inputs are summarized and compared prior to the specification of a recursive system of equations. The four inputs investigated are pesticides, petroleum products, farm machinery and repair parts for farm machinery. A Nerlove adjustment model is used for pesticides and farm machinery.

The Canadian demand for pesticides was generally increasing throughout the period investigated (1962-1977). Eastern Canadian demand was more sensitive to price and farm revenue changes than Western demand. A time period of one year is required to adjust the actual level of investment to the desired one in Eastern Canada while Western farmers take approximately three years or so.

Expenditures on petroleum products were increasing slightly but constantly between 1962 and 1977 in Western Canada. Eastern expenditures increased until 1972 but decreased significantly by 1977 to reach a level which was 31% lower than in 1972. The behaviour of the demand in the East was partly due to the price effect since the real price of petroleum products decreased constantly until 1972 but increased substantially from 1973 on. Western Canada did not react as much to the price effect since Western agriculture is more capital intensive and, apparently, no close substitutes are available.

The demand for farm machinery has been cyclical in both Eastern and Western Canada with peaks in 1948-53, 1963-67 and 1973-77. The stock of farm machinery was relatively constant until 1972 because the first and second cycles were similar. The span of time required to adjust the actual level of investment to the desired one appears to be about five years in Eastern Canada and ten years in Western Canada.

The behaviour of the demand for repairs differed between East and West. In Eastern Canada, expenditures have been increasing throughout the period investigated except for the last four years where they were constant. Western expenditures were constant until 1971, increased until 1974 to reach a level 65% higher than their previous level and then dropped by 14% during the last three years. The higher elasticity of the demand for repairs with respect to the age of the stock in the West and a lower elasticity with respect to the revenue variable suggest that Western farmers are less inclined to repair machinery.

Forecasts for 1979 and 1980 show the quantity demanded for pesticides in Canada is expected to continue its upward trend and reach levels of $250 million and $300 million respectively, of which 65% will be used in Western Canada. In 1979, Canadian expenditures on petroleum products are expected to stay at the same 1978 level namely, $520 million, but are expected to increase by 10% in 1980 up to $570 million. This increase in 1980 is expected to occur due to Western Canada only since Eastern expenditures are expected to be constant at their 1978 value. Expenditures on farm machinery are expected to remain at the same level in 1979 as they were in 1978 in both Eastern and Western regions. They are however expected to increase by 15% in the East and by 10% in the West in 1980 to reach a level of $520 million and $930 million respectively. As to the demand for repair parts, it is expected to increase by 25% and 15% in 1979 and 1980 in Eastern Canada to the levels of $100 million and $115 million respectively. Western Canadian demand is expected to increase by 10% in both 1979 and 1980 to reach $125 million and $140 million respectively.

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CHAPTER ONE

PROBLEM STATEMENT AND OBJECTIVES

Introduction

Resources demanded by the agricultural sector have been studied for a number of countries in the past twenty years. The investigations can generally be divided into two groups, durables and non-durables. Most studies utilize a single demand equation for each input. Generally, the equations are derived from an hypothetized production relationship which is assumed to prevail in all countries or regions if the study is cross-sectional, or throughout a given period for a time series analysis. For Canada, several time-series analyses recognized the diversity of input demand relations between different areas and are disaggregated into regions with similar agronomic practices and institutions.

Any input demand derived from a production function is related to the other inputs via relative prices. This theoretical relationship does not account the multitude of constraints which farmers have to allow for when purchasing different inputs(1). Such constraints may be of the form of

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(1)A discussion of derived input demands is provided in Chapter Four, section Farm machinery, in the "Related material" subsection.

indivisibility of a specific input, limited substitution, potential working capability measured either in capital or human "units" ...; as well as personal tastes and objectives. Of course, many of these constraints would be difficult to embody into a model due to their subjective nature and/or unavailability of the relevant data. However, it is clear that a single equation specification in an econometric model cannot reflect all the complexity involved in the decision process. Consequently, a set of equations should be provided, even when only one specific input demand is investigated, to account for the simultaneous effects on related variables. Such a set of equations is necessary if the model is designed to forecast the quantity demanded of the investigated input. Single equation estimators by failing to reflect the interaction among the various inputs demanded are less likely to respond to changes in conditions and hence may fail to forecast turning points.

Policy planning and its possible impacts on the economy are a major concern of governments. In this context, the Canadian ministery of agriculture lacked an analytical system capable of evaluating the effect that new or existing programs have on aggregate investment and annual purchasing decisions by the primary Agricultural sector. For example, the influence that income stabilization, price support or taxation policies have upon expenditures by farmers and ultimately net income should be examined prior to the implementation of a program and during its fruition. In September 1977, Agriculture Canada contacted many Canadian universities to cooperate in developping an aggregate model to reflect the significant economic relationships in the agricultural sector. The Department of Agricultural Economics at the University of Manitoba undertook the section on forecasting farmers' annual expenses (except feed grains) and long term investments. The present study is a part of this extensive model.

Scope and objectives of the study

The present study concentrates on the demand for agricultural pesticides; petroleum products (gasoline, diesel fuel, oil and lubricants); farm machinery; and repair parts for farm machinery. The main objectives of this study are to:

i) summarize the major non-Canadian studies on the demand for durables in order to have a precise notion of their respective models;

ii) review and criticize the Canadian studies on the demand for agricultural durables;

iii) develop a system of equations to reflect the interdependance of the demand for the four previously mentioned agricultural inputs;

iv) examine and compare the historical quantity of each input purchased in Eastern and Western Canada;

v) estimate empirically the structural parameters of the demand functions for the aforementioned agricultural inputs;

vi) compare the estimated results between Eastern and Western Canada in order to determine whether differences in responses of the two regions to the hypothetized explanatory variables exist;

vii) simulate the input demands through a recursive system of equations and to compare the simulated results in order to test the performance of the model and;

viii) provide forecast estimates of the demand for the four inputs investigated over the period 1978 to 1980. Forecast estimates for 1978 will be compared to actual values.

The study has been disaggregated into Eastern and Western Canada due to the heterogeneity of agricultural production throughout Canada. Western Canada is more land and capital intensive on a per farm basis. In 1960, the stock of farm machinery per Eastern Canadian farm was 54% of a Western Canadian farm but by 1978, the ratio increased to 79%. This was due to a higher rate of increase in the capital stock in the East during the seventies and a greater decline in the number of farms. (See Chart 4.9 and Chart 8 in Appendix C). However, the average land holding per farm increased in both regions during the period investigated (1962-77) and remained more than four times greater in the West than in the East (See Chart 7 & 8 in Appendix C).

In order to achieve the foregoing objectives, the study is divided into three major sections. Chapter Two reviews the literature on input demand by the agricultural industry. More emphasis is given to the Canadian studies but significant non Canadian articles are dealt with. Chapter Three describes the model specification. The first section describes each input demand relationship while the complete recursive system is developed in the last part. Chapter Four provides the empirical estimates for each regional input demand as well as forecasted estimates for the period 1978-80. Lastly, Chapter Five summarizes, elaborates upon important results of the study and points out its limitations.

CHAPTER TWO

LITERATURE REVIEW

Introduction

The present study concentrates on the demand for pesticides, energy, farm machinery and farm machinery repairs. Since few published studies exist on the agricultural demand for pesticides, energy or farm machinery repair parts, the following discussion reviews studies on the demand for farm machinery.

The demand for farm machinery has been investigated by several authors and for many countries. The most renowned studies are from the United States (Cromarty; Griliches; Heady & Tweeten; Fox; Rayner & Cowling). Others are from the United Kingdom (Rayner & Cowling; Scott & Smyth), and Canada (Haver & Grove; Dhruvarajan; Fujitani; Brasnett; Hazledine). All these studies (except Cromarty) use exclusively single equation specification. In Canada, the sole model that dealt with a complete set of equations for the agricultural sector was developed by Denton, Freshwater & Robb for the Food Prices Review Board. The study investigates total capital formation in agriculture and forecasted values are provided under three different assumptions about prices and farm credit extended. However, as the present study concentrates on specific input demand, the Denton, Freshwater & Robb study will not be discussed here.

Because many of the non-Canadian studies have been reviewed before (see for instance Rayner & Cowling; Haver & Grove), only the general hypothesized relationships between dependant and independant variables are mentioned. In addition, the statistical significance of the relationships and their expected theoretical signs are pointed out. This has been done to show the different model specifications employed in each study and to obtain a better understanding of why they differ. The empirical results of the Canadian studies however are analysed in greater depth.

Foreign studies

Cromarty

The first major study on the demand for durables in agriculture was completed by W.A. Cromarty in 1959. For path breaking research, the study was rather "complete". It analysed the demand for all machinery, tractors and trucks using both single equation system estimated by ordinary least squares (OLS) and a simultaneous system using the maximum likelihood limited information method (MLLI). Moreover, he also investigated the supply of farm machinery and tractors which has not been replicated.

The hypothesized equations for machinery and tractors and the significance of the parameters are summarized below(2).

Farm Machinery.

i) Demand equation: estimated by OLS for the period 1923-54.

$$Y1 = f(Y2, X1, X2, X3, X4, X5, X6, X7) \quad (2.1)$$

where:

Y1 = manufacturers' sales of farm machinery deflated by the wholesale price index for farm machinery;

Y2 = wholesale price index of farm machinery deflated by the general price level for all commodities: shows the hypothesized (-) sign but statistically insignificant;

X1 = price index of output (crops and livestock) deflated by the general price level for all commodities: hypothetical (+) sign but statistically insignificant;

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(2)All estimated equations are linear.
Y's are endogenous and X's are exogenous variables.

X2 = price index of all inputs excluding wages deflated by the general price level: hypothetical (-) sign but statistically insignificant;

X3 = stock of farm machinery in constant dollars: hypothetical (+) sign but statistically insignificant;

X4 = value of farm assets in constant dollars: hypothetical (+) sign and statistically significant;

X5 = realized net income for the previous year: hypothetical (+) sign but statistically insignificant;

X6 = average acreage of cropland per farm: hypothetical (+) sign but statistically insignificant;

X7 = index of farm labor costs deflated by the general price level: wrong hypothetical (-) sign but statistically significant.

ii) Demand equation: estimated by MLLI for the period 1926-55 omitting 1943.

$$Y3 = f(Y4, X8, X4, X9, X10) \qquad (2.2)$$

$$Y4 = f(Y3, X11, X12) \qquad (2.3)$$

where:

Y3 = domestic farm machinery shipments in constant dollars: hypothetical (+) sign and statistically significant;

Y4 = retail price index of farm machinery deflated by the general price level: hypothetical (-) sign but statistically insignificant;

X8 = ratio of prices received by farmers to prices paid by them: wrong hypothetical (-) sign and statistically insignificant;

X4 = defined previously: hypothetical (+) sign but statistically insignificant;

X9 = industrial wage rate deflated by the general price level: hypothetical (+) sign and statistically significant inasmuch as the substitution effect is concerned where off farm migration requires greater capital intensity on remaining farms;

X10 = a quantified variable to measure the farm price programs: hypothetical (+) sign but statistically insignificant;

X11 = wholesale price index of farm machinery deflated by the general price level: hypothetical (+) sign and statistically significant;

X12 = variation in inventories in constant dollars: the sign could be either (+) or (-) but the parameter is not significant anyway.

iii) Supply equation: estimated by MLLI for the period 1926-55 omitting 1943.

$$Y5 = f(Y3,\ X13,\ X11,\ Y6) \qquad (2.4)$$

where:

Y5 = value of farm machinery produced in constant dollars;

Y3 = defined previously: hypothetical (+) sign and statistically significant;

X13 = price per ton of steel in constant dollars: hypothetical (-) sign but statistically insignificant;

X11 = defined previously: hypothetical (+) sign but statistically insignificant;

Y6 = a measure of plant capacity i.e. the average value of machinery produced during the past three years: hypothetical (+) sign but statistically insignificant.

Tractors.

Equation 2.5 has been estimated by OLS and MLLI for the period 1926-55 omitting 1943.

$$Y1 = f(Y2, X1, X2, X3) \tag{2.5}$$

where:

Y1 = manufacturer's shipments of wheel type tractors in units;

Y2 = ratio of the retail price of tractors to the price of output: both methods estimate a statistically significant hypothesized (-) sign;

X1 = net cash receipts of the previous year: both methods estimate a statistically insignificant hypothesized (+) sign;

X2 = 8-year average of number of tractors on farms in units: both methods estimate a statistically significant positive sign;

X3 = average sales of tractors for the previous five and six years in units: both methods estimate a statistically significant positive sign.

The major criticisms found in the literature of the aforementioned models are that: (see for instance Hugues; Haver & Grove; Brasnett)

i) machinery is a durable input and producing a flow of services for more than one period is not taken into account;

ii) gross investment is utilized rather than net investment and a "one-hoss-shay" depreciation pattern is assumed;

iii) the stock adjustment process is intrinsically assumed to take place within one year;

iv) manufacturer's shipments of tractors are used instead of farm purchases and;

v) units used do not account for changing quality over time.

<u>Griliches</u>

Griliches extended Cromarty's work by accounting for the stock adjustment process. He proposed farmers were aiming to achieve a "desired" stock of tractors "S " and the adjustment process was of the following form for for a linear production function:

$$S - S(-1) = k(S \quad - S(-1)) \tag{2.6}$$

or

$$((S/S(-1)) = (S \quad /S(-1)) \tag{2.7}$$

for a Cobb-Douglas production function. In equation 2.6 and 2.7, "S" is the actual stock of tractors and "k" the adjustment coefficient. Therefore, the estimated short-run stock demand equation is of the form:

$$\ln S = ka0 + ka1 * \ln X1 + ka2 * \ln X2 + (1-k) * \ln S(-1) + ku \tag{2.8}$$

where the X's are the exogenous variables.

Griliches also specified a "flow-demand" equation where the dependant variable is the annual purchase of tractors. An implicit semi-logarithmic demand function is assumed and after algebraic transformations, the estimated gross investment equation is of the form:

$$G = k * \ln a0 + ka1 * \ln X1 + \ldots + (d-k) * S + v \tag{2.9}$$

where:

G = gross capital expenditures on tractors in constant dollars;

X's= the exogenous explanatory variables;

d = depreciation rate;

k = the adjustment coefficient.

In a first attempt, the exogenous variables were the ratio of the price of tractors to the price of output (crops) and the rate of interest. In both models, they appeared to be statistically significant with the expected signs. In order to improve the results, Griliches also tried additional variables with the following results:

i) price of tractors relative to the price of labor: wrong hypothetical (+) sign and statistically insignificant;

ii) stock of horses and mules on farms: hypothetical (-) sign but statistically insignificant;

iii) real equity (only in the investment model): wrong hypothetical (-) sign and statistically insignificant;

iv) price of tractors relative to price paid for motor supplies (only in the investment model): hypothetical (+) sign but statistically insignificant;

v) time trend variable (only in the investment model): statistically insignificant.

A major shortcoming in Griliches' investment model is that separate values for the depreciation rate and the coefficient of adjustment are not identified. Therefore, the depreciation rate must be determined from other sources.

The major findings of the study are that the stock-price elasticity of demand is about -0.25 in the short-run and -1.5 in the long-run. The interest elasticity is about -1.0 in the short-run and -5.8 in the long-run. Assuming a depreciation rate of .23, a value determined by the USDA, the adjustment coefficient would be about .17. This means the "desired" stock would be reached in about five years; a rather long adjustment period as the author himself recognizes.

<u>Heady & Tweeten</u>

In their extensive study on farm machinery and different specific inputs, Heady & Tweeten elaborated a series of models based mainly on those proposed by Nerlove, Koyck and Griliches. They estimated short-run models and compared them with stock-adjustment and investment-adjustment models. Most of the models were estimated using the least-squares approach although the maximum likelihood limited information technique was also used to estimate a system of equations. Several models were estimated using both original and logarithmic data. For the models estimating total farm machinery demand, dependant variables were expressed in constant dollars and the exogenous variables used in all models were:

i) the price of machinery to the price of output ratio: hypothetical (-) sign and statistically significant;

ii) an income variable which was either; net income of the past year, a declining three-year arithmetic average of net income, or the equity to liabilities ratio: hypothetical (+) sign and statistically significant;

iii) a trend variable: statistically significant.

No statistical significance could be shown for any other tentative explanatory variables. Among them was the ratio of the price of machinery to the price of labor which, moreover, had a wrong hypothetical (+) expected sign.

With respect to the stock-adjustment models, the parameter of the stock variable statistically was not different from zero which suggests the adjustment coefficient and the depreciation rate are equal to each other. This could be interpreted as the occurence of no net investment during the period under investigation.

For the investment-adjustment models, the lagged dependant variable is not statistically significant. In other words, the adjustment coefficient is not different from unity. The following explanation was given by Heady & Tweeten:

> The low significance of the coefficient of Qn(t-1) (the lagged dependant variable) would suggest that farmers adjust purchases to the desired or equilibrium level in the short-run if they are subjectively certain of favorable prices, income and other explanatory variables; and that the adjustment model is inappropriate for annual gross investment. (Heady & Tweeten, pp. 226).

Their analysis indicated log-linear equations give less acceptable estimates than linear functions and that

> the Limited Information equation, as we have specified it, is less acceptable than selected ones of our least-squares equations for expressing machinery demand. (Heady & Tweeten, pp. 299).

Because Heady & Tweeten specified and tested several types of equations to reflect machinery demand, a critic claimed that this approach is inferior from a theoritical point of view since

> No a priori hypothesis was made for either: (1) the inclusion of the most relevant economic variables or (2) the form of the best model ... specifying the models in various forms does not resolve the problem of identifying the causes of structural change in resource demand. (Brasnett, pp. 18)

Brasnett also mentioned that more emphasis should have been paid to substitution and complement effects. Indeed, the ratio of the price of machinery to the price of labor had been used in only one equation and as it was not statistically significant, it was dropped and was replaced by other variables which reflect the complementary relationship between machinery and other inputs.

Fox

In previous studies, the problem of quality change over time was not accounted for. Austin Fox proposed to measure investment and stock of tractors in terms of horsepower. The best statistical equation embodied the following explanatory variables:

$$H = f(X1, X2, X3, X4, X5, H(-1)) \qquad (2.10)$$

where:

H = horsepower purchases in the current year;

X1 = ratio of the price of tractors to the price of output: negative (-) sign and statistically significant;

X2 = average size of tractors purchased: positive (+) sign and statistically significant;

X3 = average age of tractors on farms: negative (-) sign and statistically significant;

X4 = number of farms: positive (+) sign and statistically significant;

X5 = crop production in the current year: (the way he measured this variable is not given) positive (+) sign and statistically significant;

H(-1) = Horsepower on farms at the beginning of the year: positive (+) sign and statistically significant.

Results show that all regression coefficients are highly significant. However, as mentioned in the literature, Fox failed to use the appropriate price ratio and should have used the price per horsepower rather the price of tractors.

Other foreign studies

Two other major studies on the demand for durables in agriculture were performed by Rayner & Cowling for the United Kingdom and by Scott & Smyth for Western Europe. They focus mainly upon the demand for tractors.

Rayner & Cowling stress the impact of quality change over time and developped a constant quality price index (Rayner & Cowling pp. 593). Both investment-stock and stock-adjustment models were specified. The dependant variable in most equations was gross investment measured according to the full quality measure. The independant variables used and their respective statistical degree of significance were:

i) ratio of the "real" current price of tractors to lagged price of output: wrong hypothetical (+) sign and not statistically significant;

ii) ratio of the "real" current price of tractors to lagged price of labor: hypothetical (-) sign and statistically significant;

iii) percentage of investment allowance: hypothetical (+) sign and statistically significant;

iv) lagged value of the stock in constant dollars: hypothetical (-) sign and statistically significant.

Average farm size and advertising expenditures were also included in previous specifications but were insignificant.

In the stock demand based on stock-adjustment models, where all variables were expressed in logarithms , the best statistical equation used the same variables mentioned above but this time, all coefficients showed the expected sign and were statistically significant.

They concluded that the stock demand based on a stock-adjustment model performs better than the investment-stock-adjustment model. The dependant variables have to be expressed in values deflated by real price since other types of measurements, namely total horsepower, the number of tractors weighted by horsepower or the number of tractor alone did not perform as well. Of course, one would expect the new price index developed to be very important. They extolled its virtues in the following terms:

> The dominating explanatory variable of this adjustment (stock adjustment) is the ratio of tractor price to labor earnings, allowing for quality change in tractors. The estimated long-run elasticity of stock with respect to this variable is quite high being -0.97. The short-run elasticity is -0.66. (Rayner & Cowling, pp. 596).

Scott & Smyth's study on tractors was undertaken for the Canadian Royal Commission on Farm Machinery. It could be divided into two studies using the same theoretical framework where one was a cross-section analysis over sixteen Western European Countries and the other a time-series using British data. The study using cross-sectional data assumed a CES production function and profit maximization. From this basis, they were able to estimate the derived demand functions for tractors and this particular specification provides an estimate of the elasticity of substitution. Empirical results showed an elasticity of substitution between tractors and labor significantly greater than one. Therefore, assuming the first order conditions are met, any variation in the relative price ratio would be followed by a greater relative substitution between the two inputs considered. Scott & Smyth also considered the influence of farm size on the relative utilization of tractors versus labor. They concluded that farm size has a positive impact on the ratio of tractors to labor. The greater the average farm size, the higher the tractor to labor ratio. However, it is not obvious that farm size affects the tractors to labor ratio rather than the other way around..... More machinery per man would lead to potentially more land per man and thus, increasing farm size would be a result of an increasing capital-labor ratio and not the cause.

In the time series analysis, Scott & Smyth also used a CES production function with the assumption of profit maximization. In the model specification, they assumed the actual stock is related to the optimum/desired stock by means of a Gompertz curve(3). They also assume that actual and optimal level of labor employed are related to each other by the same type of function.

The estimated model takes the form of:

$$\ln(S/S(-1) = C + as*\ln(Pl/Pt) + (a/b)*\ln(L/L(-1)) \\ -a*\ln(S(-1)/L(-1)) \qquad (2.11)$$

where:

S = stock of tractors (total horsepower);

Pl = price of agricultural labor;

Pt = "constant quality" price of tractors as developped by Rayner & Cowling;

L = agricultural labor;

a = tractor adjustment coefficient;

b = labor adjustment coefficient;

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(3)For the theoretical derivation of the model, see Scott & Smyth pp. 59-65.

as = short-run elasticity of substitution;

s = long-run elasticity of substitution.

Results show all parameters have the expected theoretical sign at a statistically significant level. However, depending upon the specification of the dependant variable (numbers or horsepower available), there is a wide range of variation in the estimates of elasticities of substitution and adjustment coefficients. Therefore, the stability of the model suffers and the credit of the hypothesized production function or the Gompertz curve type of relationships between the actual and the optimum/desired stock or the actual and optimal level of labor employed are doubtful.

Canadian studies

To facilitate the discussion of the Canadian studies, they will be divided into two groups: those dealing with aggregate farm machinery investment and those with specific input purchases.

In the first group, the studies to be discussed were performed by Haver & Grove, Dhruvarajan, Fujitani and Brasnett. Haver & Grove and Brasnett also have chapters related to specific durable input demands and they, together with Hazledine, will be discussed in the second group.

Demand for farm machinery

Most of the studies mentioned above recognized that farm machinery demand is not homogenous throughout Canada. Therefore, different equations were estimated by regions and as it will be shown, the structural relationships are often quite different from one region to another.

The first major econometric research on farm machinery demand in Canada was undertaken by Haver & Grove for the Canadian Royal Commission on Farm Machinery. The models used were similar to those reviewed by Griliches, namely gross-investment-stock adjustment and gross- investment adjustment models(4). This study was the only analysis which aggregated all provinces into a single entity. The period investigated was from 1946 to 1966.

Dhruvarajan, in another study for the Royal Commission disaggregated the demand for farm machinery according to regions in Canada. The time period he investigated was from 1926 to 1967 and the models used were of the following types:

a) stock demand equations based on stock adjustment models,

b) investment demand equations based on investment adjustment models,

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(4)See Appendix A for the derivation of such models.

c) investment demand equations based on stock adjustment,

d) demand equations with no adjustment models.
(Dhruvarajan pp. 13)

Dhruvarajan specified a model similar to the one developed by Scott & Smyth for Europe and investigated the stock and/or labor adjustment resulting from the assumption of a CES production function for Canadian agriculture. The period he investigated was from 1926-41, 1952-67.

Fujitani also tested the same model developped by Scott & Smyth for the period 1960-74 with Canadian data.

Most recently, another study undertaken by R.A. Brasnett investigated farm machinery demand in Canada. The study concentrates exclusively on the five principal regions i.e. Maritimes, Quebec, Ontario, Prairies and British Columbia. No results are given for Canada as a whole. Here again, different models are tested for the period 1961-76 i.e. stock demand and gross-investment demand based on stock-adjustment and investment-adjustment.

Results of the Canadian Studies.

Even though each model has unique characteristics such as the functional form and definitions of variables, the similarities and differences will be pointed out whenever possible.

The explanatory variables used in Haver & Grove's investment-stock-adjustment models were the ratios of the price of machinery to the price of labor and output, gross cash receipts in the current year deflated by the Consumer Price Index (CPI), the number of farms and the average farm size with, of course, the stock of machinery. Their results show that all parameters are statistically significant except the ratio of the price of machinery to the price of output. This ratio has a negative sign though, which is theoretically expected. However, the ratio of the price of machinery to the price of labor does not have the theoretical expected sign but appears to be statistically significant. No rational or tentative explanations were provided by Haver & Grove for the contradictory positive sign. For the income variable, they used lagged net income but came to the conclusion that gross cash receipts in the current year was a better explanatory variable. By using gross cash receipts in the current year, there are some intrinsic assumptions which are difficult to accept. For instance, perfect knowledge of future cashflows is assumed and farm operating expenditures are always a constant proportion of total cash receipts. If this latter assumption does not hold then cashflow actually available for investment should be used.

Haver & Grove also attempted to use annual sales of repair parts lagged one period as explanatory variable. It however did not appear to have any statistical significance. One could have expected such a result since annual expenditures on repair parts are meaningless unless they are related to a given stock of machinery for which the parts are bought. Indeed, sales of repair parts could go up but if investment in machinery increases at a higher rate, farmers are actually buying fewer repair parts per machine or vice-versa.

The best statistical regressions show an elasticity of about -0.1 to -0.3 for the ratio of the price of machinery to the price of output; about 1.9 for the revenue variable; between 1.4 and 2.0 for the price of machinery to the price of labor and a very high, negative stock-adjustment coefficient of about -0.6 assuming a depreciation rate of 0.12. Using the linear equation though, the adjustment coefficient is about 0.05 which is still lower than any depreciation rate normally assumed for farm machinery. Therefore, according to these results on the coefficients of adjustment, farmers are overcapitalized and the optimum stock of farm machinery should be reduced. However, one equation was estimated for the period 1935-66 omitting the war years (1940-45) and the coefficient of the stock variable was not statistically different from zero. This implies the depreciation rate does not differ significantly from the stock adjustment and the stock of farm machinery remained the same throughout the period under investigation.

Haver & Grove also tested the investment demand model based upon investment adjustment. The explanatory variables used were: the ratios of the price of machinery to the price of output and the price of labor, gross cash receipts in the current year and the lagged endogenous variable. Here again, the regression coefficient on the price of machinery to the price of labor had the wrong expected sign but was not statistically significant. The values estimated for the regression coefficients were comparable to the stock-adjustment specification mentioned above. The investment-adjustment coefficient varied between 0.5 and 0.6 depending whether the data were in original or logarithmic form.

A study by Dhruvarajan followed the Haver & Grove's analysis. As this study is rather extensive and disaggregates the input demand function by regions (Maritimes, Quebec, Ontario, Prairies, British Columbia), only the best equations will be discussed hereafter.

For the investment demand model based on a stock-adjustment process, the basic equation includes only the ratios of the price of machinery to the price of output and the price of labor with the stock variable. Later on, Dhruvarajan added variables such as interest on indebtedness, average farm size, farm revenue defined in different ways and a time trend. Best results for Canada were from the basic equation plus the time trend variable. As the equation was expressed in a semi-logarithmic form i.e. some explanatory variables were expressed in logarithms and others in natural numbers, elasticities had to be calculated and the ones available are those for the price ratios. The investment demand elasticity in terms of the ratio of the price of machinery to the price of labor shows a value of -0.80 and for the ratio of the price of machinery to the price of output a value of -0.29. This latter result is quite similar to the one found by Haver & Grove. However, the investment demand elasticity in terms of the machinery-labor price ratio had the expected sign and was smaller than one. Haver & Grove found this coefficient always positive and most of the time greater than one. A possible explanation might be that Haver & Grove had an income variable in their equation specification since, when Dhruvarajan included this variable, the coefficient of both price ratios became positive although not statistically significant. The explanation given by Dhruvarajan for the change in the signs of the price ratios is " that the constraint imposed by lagged income is stronger than the price effect." (Dhruvarajan pp. 18). As to the adjustment coefficient, Dhruvarajan mentions a value of 0.29 while using a depreciation rate of 0.23 which is the value used by

USDA for tractors(5). As the data utilized are secondary data obtained from Statistics Canada, he should have used the depreciation rate employed by them which is about 0.12. Assuming a depreciation rate higher than the actual one used to determine the data series causes the influence of the stock variable to be underestimated since it is assumed that values used have been depreciated at a higher rate than they actually have been. Anyhow, it would be intrinsic nonsense to further discuss any results obtained by assuming a depreciation rate higher than the one actually used to develop the data series in the first place. The stock of machinery is merely the summation of annual investment minus the depreciation that occured over the year. Therefore, investment during a given year is in some way boosted upward when transferred to the right hand side of the equation through the stock variable since it is assumed to have been depreciated at a higher rate than it was actually by Statistics Canada. Therefore, such model would collapse if used for forecasting purposes since any attempts to simulate the impact of a given policy affecting an exogenous variable or merely straight forecasted values with different assumptions about the behaviour of exogenous variables need a proxy which must be calculated for the stock variable. But the value of the stock will be underestimated and hence, the forecasted investment value will also be underestimated.

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(5)See Griliches in Harberger pp. 189.

Also, to use a higher depreciation rate misleads the relationship between short and long run effects of a variation in any exogenous variable. Indeed, when the long run effect of the explanatory variables on the endogenous variable are derived using the coefficient of adjustment, as this latter has been overestimated, the long run influence is dampened and any medium run policy based on the results of such a model may have considerable unexpected repercussions.

For the same equation specification, i.e. the investment-stock-adjustment model, the coefficients of elasticities for the regions are quite different than those mentioned above which are for Canada. The investment demand elasticity with respect to the ratio of the price of machinery to the price of output ranges from -1.35 in Quebec to -1.80 in Ontario and Prairies; values much higher than -0.30 found for Canada. For the ratio of the price of machinery to the price of labor, the coefficient of elasticity appears to be positive in Quebec and Ontario with a value of about 0.30 but quite close to Canada's value in Western Canada with a coefficient of -0.70. As to the stock-adjustment coefficients, assuming a depreciation rate of 0.12, they all have a value between 0.16 and 0.17 which is similar to estimated value for Canada as a whole. Hence, it seems that the time span required to reach the optimum level of stock is rather long and homogenous throughout Canada, being about five years.

With respect to Dhruvarajan's investment demand based on an investment-adjustment model, the explanatory variables of the best equation for Canada were the two price ratios and the lagged endogenous variable, plus a lagged net farm income variable and the interest on indebtedness. Statistically, the results were not as good as for the stock-adjustment model since only the regression coefficients for net farm income and interest on indebtedness were significant. The coefficients of elasticities of the price variables had the correct expected signs and were about the same for the two ratios with values between -0.08 and -0.09 but were not statistically significant. Therefore, the elasticity of the ratio of the price of machinery to the price of output is about the same as Haver & Grove's findings and the other price ratio coefficient of elasticity seems to be a little more acceptable theoretically with the expected sign. However, even with the expected sign, both parameters were not significantly different from zero which implies the demand for farm machinery is not influenced by the price levels. With respect to the investment adjustment coefficient, it is high (0.85) and not significantly different from unity. This implies farmers adjust their actual investment level to the optimum or desired one within the same year. This is a shorter period than Haver & Grove's results which gave a time adjustment period of about two years. Unfortunately, results for regions are not available for this particular type of model.

For the stock demand based on a stock-adjustment model, the two coefficients of the price ratios did not show any statistical significance and the ratio of the price of machinery to the price of labor even had the wrong expected sign in most equations. Real cash receipts from agricultural sales lagged one period was most of the time highly significant with the expected sign. The stock-adjustment coefficients seem somewhat low with values of 0.10 for Canada and the regions. However, using a simple stock-adjustment model where the optimum level of stock is a function of the price ratios and the trend only, Dhruvarajan tried to improve this model by making the adjustment coefficient a function of lagged cash receipts. Results at the mean show an adjustment coefficient of 0.23 for Canada. Unfortunately, numerical results for regions are not available but a table of Dhruvarajan's reporting the signs and statistical significance of the parameters shows that signs are as expected and statistically significant.

Fujitani and Dhruvarajan tested the stock-adjustment model, using the assumption of a CES production function developed by Scott & Smyth(6), with Canadian data. Here again, Dhruvarajan's numerical results are not currently

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(6)See the functional relationship mentioned previously.

available and the only discussion he provides is:

> Regression (2) shows that although L/L(-1) (labor ratio) has the expected positive sign for all regions, in no case is it significant, indicating that g/b (stock-adjustment/labor adjustment) is close to zero or that "b" is high relative to "g" or that labor requirements are met quickly. (Dhruvarajan pp. 38).

The elasticity of substitution between capital and labor in Fujitani's paper appears to be extremely high in Canada with a value of 61.60. Results for provinces are more admissible ranging from -0.84 in Quebec to 2.37 in Alberta with values of -5.0 in Maritimes and -6.04 in British Columbia. However, any interpretation of these results would be doubtful and possibly meaningless since the sign of the elasticity of substitution is often negative due either to a positive sign for the ratio of the price of machinery to the price of labor or to a negative machinery adjustment coefficient. Furthermore, it happens that the elasticity of substitution is positive but this results from the wrong expected sign on both parameters which are used to calculate it, i.e. the ratios of the price of machinery to the price of labor and the stock of machinery to labor available.

Fujitani also tested the stock-demand-stock adjustment model as well as the investment demand-stock adjustment for the period 1960-74. Besides the price ratios, realized net income lagged one period and average farm size were used. The price ratios showed the expected sign in both types of model although the price of machinery to the price of output was generally more significant. The income variable, rarely significant, showed a positive sign in the investment-stock adjustment model but appeared to be negative in Canada, Maritimes and Quebec in the stock demand-stock adjustment model. The average farm size was not significant but positive in the investment-stock adjustment model. It was negative and significant in the Eastern provinces, British Columbia and Canada but positive and significant in the Prairies for the stock demand-stock adjustment model.

The coefficients of adjustment in the stock demand-stock adjustment model are not very reliable either since they are greater than one most of the time for the provinces. However, its value for Canada is about 0.85 which seems reasonable but is greater than Dhruvarajan's findings. It should be mentioned that Dhruvarajan's model was not specified the same way as mentioned above, with the adjustment coefficient being a function of income. The investment demand-stock adjustment model gives a coefficient of adjustment similar in both studies i.e. Fujitani's and Dhruvarajan's, with values of 0.83 in Canada and approximately 0.35 in the East versus 0.2 in the West. These values are not reconcilable since if it takes three years in Eastern Canada and five years in Western Canada to adjust their stock to the optimum level, how could it take only one year in Canada?

The most recent study related to the demand for farm machinery in Canada has been undertaken by R.A. Brasnett. He used three main types of models: the stock demand-stock adjustment; the investment demand-stock adjustment; and the investment demand-investment adjustment . The specification of the equations is consistant for all models namely the endogenous variables and the lagged endogenous variables or the lagged value of the stock in the investment-stock adjustment model are all in original form whereas other explanatory variables are in logarithms, which is exactly the same specification employed by Griliches. It is consistant also in the sense that in all models, the exogenous explanatory variables are the ratios of the price of machinery to the price of output and to the price of labor, the average farm size lagged one period and the interest rate, corresponding to the Chartered Banks Prime Business Loans Rate. All these variables are used together in one equation. Due to multicollinearity problems, two other equations were estimated for each province; one without the average farm size and the other without the ratio of the price of machinery to the price of labor. Numerical results related to the coefficients of elasticities have to be calculated due to the semi-logarithmic specification of the equations. Two values are presented; one at the sample mean and one for the year 1975.

In the stock demand-stock adjustment model, contrarily to Dhruvarajan's results, the ratio of the price of machinery to the price of output has the correct expected sign and is significant in all regions except British Columbia. The ratio of the price of machinery to the price of labor however, shows the negative expected sign but is statistically significant only in equations where the average farm size does not appear. Multicollinearity seems to be the cause of such phenomenon since one of its consequences is that the standard error of the estimates becomes very large. As for the interest rate, it shows the expected negative sign in about half of the equations but is seldom significant statistically. The adjustment coefficients are always significant, except in Ontario, and the period of adjustment seems to be about ten years in Eastern Canada versus two or three years in Western Canada.

The investment demand-stock adjustment model is not as good statistically as the model described above. The sole variable which is generally significant is the ratio of the price of machinery to the price of output although the other variables generally show the right expected sign. The parameters of the lagged stock variables are not significant and the coefficients of adjustment, assuming a 0.12, depreciation rate are negative. Practically speaking, these results lead to the conclusion that there is no significant difference between the stock coefficient of adjustment and the depreciation rate. Therefore, investment demand was merely replacing the obsolete stock during the period under investigation; a conclusion which is also valid for Fujitani's provincial results.

Again in the investment demand-investment adjustment model, the ratio of the price of machinery to the price of output is the variable which is the most significant. However, the others also have the expected signs and are significant most of the time. It should be pointed out though that the interest rate appears to be highly significant in Western Canada but not in the East. The coefficients of adjustment vary between 0.25 and 0.35 in Quebec and Maritimes; 0.35 and 0.45 in the Prairies to reach 0.60 in Ontario. British Columbia has the lowest adjustment coefficient with a value of .06. Theoretically, these results are quite acceptable but unfortunately cannot be compared with other studies since a similar model for the provinces has not been tested elsewhere.

Demand for specific types of machines

As mentioned previously, Haver & Grove devote a part of their study to the demand for specific machines. They used the investment demand-stock adjustment model to estimate the demand for tractors and combines. The estimated equations for tractor demand did not show a high coefficient of determination (between 0.6 and 0.7) and the only significant variable besides cash receipts in the current year(7), is the ratio of the price of tractors to the price of labor but it has the wrong expected sign. The estimated equations for combines purchases were even worse since the R^2 were around 0.40 and the only significant variable was farm income for the current year(8). The fact that the coefficient of adjustment of the stock variable in both tractors and combines equations is not different from zero implies the depreciation rate and the coefficient of adjustment are not significantly different from each other in both cases . Although the results for the adjustment coefficients are not the best one could expect, they are still better than the ones in farm machinery demand equations since in this latter case, the coefficients were either negative or lower than the depreciation rate.

Brasnett used an investment demand-investment adjustment model for tractors with the same exogenous variables as in the farm machinery demand models (the ratios of the price of tractors to the price of output and to the price of labor, average farm size lagged one period and the interest rate). Both price ratios showed the expected signs and a high level of significance. However, equations using either the ratio

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(7)See previous discussion about using the current year value rather than the lagged value in the model specification.

(8)ibid.

of the price of tractors to the price of output, or using the average farm size performed better since those two variables appeared to be correlated in most regions. The interest rate, although showing the right expected sign throughout the provinces was not statistically significant in Eastern Canada but was highly significant in Western Canada. As to the investment coefficients, they vary widely among provinces. The Maritimes show an adjustment coefficient of about 0.7; Quebec 0.01 to 0.02; Ontario 0.4; Prairies 0.5 and British Columbia 0.1. The very small coefficient in Quebec may be due, according to Brasnett, to "bias from omitted variables" (Brasnett pp.126) and he mentioned that the most important excluded variable might be the previous year's stock. Generally, Brasnett's results seem more reliable than Haver & Grove's if one considers the overall performance of the equations as well as the stability of the parameters.

The most recent study in the field has been undertaken by Hazledine. He investigated the demand for hay balers, self-propelled combines, small and large tractors in the Prairies using "pooled" provincial data for the period 1961 to 1975. Of course this methodology forces each province to accept the same equation but the additional number of degrees of freedom

> sharply reduce the chances that the slope of the regression lines would be markedly affected by one or two outlying observations, so that their predictive power would be reduced in periods when

> whatever exogenous "shocks" that were responsible for the outliers do not repeat themselves. (Hazledine pp. 111).

Variables employed and results will not be summarized in detail here since they are not directly related to the present study and also because the estimated equations seem to suffer from several shortcomings. A few are mentioned below.

All independant variables are measured in units although the author recognizes the fact that improvements in technology are not taken into account. The addition of a trend variable does not reflect only the technological improvements. In some equations, both nominal and constant prices are used. In the balers demand equation for instance, the balers' price is deflated by the farm input price index but the steer price seems to be in nominal dollars. Another example is in the combines demand equations where the revenue variable and hired wage rate are in constant dollars but not the "average value of a combine". The revenue variable utilized in the combines demand and tractors demand equations is the average of the last two years of gross cash receipts from crops sales in constant dollars. Using gross cash receipts to explain investment demand does not reflect the amount of money available to invest since operating costs have not been taken into account. Obviously, gross cash receipts can increase but the amount of money available to invest can easily decrease if the increase in operating costs is higher. A last remark concerns the combines demand equation. In this equation, Hazledine includes the Consumer Price Index which appears to be significant and according to his "strategy" which includes

> The final specification was obtained by dropping any variables with coefficient "t" values less than one. (Hazledine pp. 112).

he had to keep it into the proposed equation! The way he rationalized it was as follows:

> Since the effect of consumer prices on purchasing power is already included in the deflated crop receipts, the variable's independant effect may be revealing the farm family's expectation about the money they will need to finance consumption expenditures. (Hazledine pp. 115)

This is an interesting rationalization for including in the equation a variable which would take into account the fact that farmers do not invest all their money in one specific input. However, this variable should have reflected money needed in real terms but then perhaps, it would no longer have been significant...

Generally however, estimated demand follows relatively closely actual demand for the period under consideration; 1961-75. However, Hazledine should have tested the appropriateness of his model in comparing actual values for 1976 and 1977 to the forecasted ones since the paper was published in december 1978.

Summary

Several models have been proposed to explain the demand for durables in agriculture. Many independant variables were specified to explain either the demand for farm machinery or for specific machines. Among them, two variables common to most studies are; the ratios of the price of the relevant input demanded to the price of output and to the price of labor. The ratio of the price of the input demanded (all machinery or one specific input) to the price of output appeared to have the right negative expected sign. It was however rarely significant in all foreign and Canadian studies. The other price ratio, i.e. the price of the input demanded to the price of labor, did not behave as well as the former. In most studies, a positive sign was estimated. The only studies where this price ratio showed the expected negative sign were Rayner & Cowling's in the United Kingdom and Brasnett's in Canada.

Other results common to most of the foregoing studies are either the stock or investment adjustment coefficients. A comparison of the coefficients of adjustment is summarized in Table 2.1.

The models most widely employed are either the stock demand based on a stock-adjustment or gross investment demand based on stock-adjustment. These two types of model

TABLE 2.1

Estimates of the adjustment coefficients.[1]

Study	Period	Country	Input[2]	Type of model[3]	Form of data[4]	k[5]
Griliches	1921-41 48-57	U.S.	T	S-S	L	0.17
	1921-57	U.S.	T	S-S	L	0.14
	1920-41 48-57	U.S.	T	I-S	S-L	0.17[6]
Heady & Tweeten	1926-42 47-59	U.S.	M	I-I	O	0.85
		U.S.	M	I-I	O	0.70
		U.S.	M	S-S	L	0.54
		U.S.	M	S-S	L	0.69
		U.S.	M	I-S	O	0.14 to 0.25[7]
		U.S.	M	I-S	L	0.42 to 0.53[7]
Rayner & Cowling	1948-65	U.K.	T	S-S	L	0.68
Scott & Smyth	1948-65	Britain	T	S-L	L	0.58
		Britain	T	S-L	L	0.21
		Britain	T	S-L	L	0.22
		Britain	T	S-L	L	0.16
Haver & Grove	1946-66	Canada	M	I-S	L	-0.70[8]
		Canada	M	I-S	O	0.05[8]
		Canada	M	I-I	O	0.50
		Canada	M	I-I	L	0.60
		Canada	T	I-S	O	0.12[8]
Dhruvarajan	1926-67	Canada	M	I-S	S-L	0.18[8]
		Canada	M	I-I	S-L	0.85
		Canada	M	S-S	S-L	0.10
Brasnett[9]	1961-76	East Canada	M	S-S	S-L	0.10
		West Canada	M	S-S	S-L	0.33 to 0.42
		All Prov.	M	I-S	S-L	0.12[8]
		East Canada	M	I-I	S-L	0.25 to 0.60
		West Canada	M	I-I	S-L	0.35 to 0.45
		East Canada	T	I-I	S-L	0.01 to 0.70
		West Canada	T	I-I	S-L	0.10 to 0.50

1. Several estimations of the adjustment coefficients appear when different dependant variables have been used into the regressions or when the dependant variable has been specified in different ways.

2. "M" means the input investigated was all machinery; "T" means the input investigated was tractors.

3. "S-S" refers to a stock demand based on a stock adjustment model;
"I-S" refers to an investment demand based on a stock adjustment model;
"I-I" refers to an investment demand based on an investment adjustment model;
"S-L" refers to a stock adjustment and labor adjustment model.

4. "O" means the data were in their original form;
"L" means the data were in logarithmic form.

5. Coefficients of adjustment.

6. Assuming a depreciation rate of 0.23.

7. Assuming a depreciation rate between 0.14 and 0.25.

8. Assuming a depreciation rate of 0.12.

9. Brasnett investigated the demand for farm machinery and tractors by provinces and no results are given for Canada. However, aggregated results shown here illustrate the range the coefficients take in Eastern and Western provinces.

give an approximation of the stock adjustment coefficients which should be theoretically the same if the assumed depreciation rate is appropriate. As far as all machinery demand is concerned, it appears the stock-adjustment is faster in the United States than in Canada according to the results of Heady & Tweeten, Dhruvarajan and Brasnett. The span of time required to adjust the actual stock to the optimum or desired one would be about two years in United States versus five years or more in Canada. The number of years required to reach the optimum or desired stock of tractors seems to be about five years in the United States and Britain according to Griliches and Scott & Smyth. However, one equation in Scott & Smyth model and Rayner & Cowling's results give an adjustment period of two years. This would seem to be more acceptable if one considers that tractors are one of the most important machines and that the adjustment period for all machinery is about two years. Nevertheless, Canadian studies also show a long adjustment period to reach the optimum or desired stock of tractors of about eight or ten years.

The other type of model tested is the investment demand based on investment adjustment which gives a proxy of the time required to adjust actual investment level to an optimum or desired one. Heady & Tweeten used this type of model in the United States and investigated investment demand for all machinery. Their results show that 70% to

80% of the adjustment would be done within a year. This is similar to Dhruvarajan's findings in Canada but the two other Canadian studies by Haver & Grove and Brasnett found the adjustment period might be a little longer and closer to two or three years in average. Brasnett also tested this model for tractors and his results are quite different among provinces which could be due, as he proposes, to data limitations and statistical problems.

CHAPTER THREE

MODEL SPECIFICATION

Introduction

One of the objectives of this study is to investigate the demand for different inputs. As the demand for land, fertilizer and "miscellaneous" inputs have already been estimated at the University of Manitoba, the present study concentrates on the agricultural demand for pesticides, petroleum products, farm machinery and farm machinery repair parts. A recursive system of equations is utilized to represent the inter-related input demands.

In order to facilitate the presentation of the model, the chapter is divided into two sections. Initially, the demand equations for the aforementioned inputs are presented. The variables embodied in the functional relationships are defined and their expected effect pointed out. Secondly, the recursive system showing the interrelations among endogenous variables and the identity equations is presented.

Single equation specification

Demand for pesticides

During the last twenty years, there has been a sizeable increase in pesticide utilization by Canadian farmers. Their useage has increased yields and total revenues have risen at a greater rate than the added chemical costs (See Dyck and Shute). Given the continual improvement and introduction of new pesticides, it is unlikely that major sectors in Canadian Agriculture are at the most profitable utilization rate for pesticides. For this reason, a Nerlove adjustment model (see Appendix A) has been specified. The hypothesized model is of the following form:

KPEST = f(RPC, REVCR(-1, DUM, TIME, KPEST(-1)) (3.1)

where:

KPEST : The dependant variable is defined as the annual value of purchases of pesticides by farmers. This value is deflated by the price index of agricultural chemicals, 1971 = 100., in order to have comparable data. But, as this index is not available prior to 1971, an estimate had to be determined for the sixties. The price index of petroleum products has been chosen since petroleum products constitute a large part of the necessary inputs for chemials production.

Source: Cansim, Matrix No. 216, 217, 229, 230, 231, 232, 233, 234, 235, 238, 2869, 2880.

RPC : Real price of chemicals, (1971 = 100.), is defined as the price index of agricultural chemicals divided by the general price level in the economy approximated by the GNE-implicit price index. The expected sign is negative although if marginal revenue exceeds marginal cost , expansion effect might overcome the price effect in a time series model.

Source: Cansim, Matrix No. 2869, 2879.

Bank of Canada Review.

REVCR(-1): Revenues from crop sales lagged one year are deflated by the GNE-implicit price index (1971=100.). The constant dollar revenues are divided by land area under crops to account for any variation in seeded area.

Source: Cansim, Matrix No. 159, 162, 163, 164, 165, 166, 167, 168, 169, 170, 216, 217, 229, 230, 231, 232, 233, 234, 235, 238.

Bank of Canada Review.

DUM : A dummy variable is defined to have the value 1 in 1969, 1970 and 1971 and 0 elsewhere. This variable has been added to reflect the high level of grain inventories in 1969, the LIFT program in 1970 and the fact that farmers did not have to use the same amount of pesticides in 1971 since several thousand extra acres were in summerfallow the previous year because of the LIFT program. This variable does not appear in Eastern Canada equation since the LIFT program was only applicable to Western Canada.

TIME : Another dummy variable defined to reflect the important trend in pesticides usage. This variable was excluded from Eastern Canada equations for statistical reasons discussed later.

KPEST(-1): The dependant variable lagged one period to determine the speed at which, ceteris paribus, farmers would adjust the actual level of chemical utilisation toward the optimum.

Source: see KPEST.

Demand for petroleum products

Petroleum products are essential inputs in agriculture and no close substitutes are available. Moreover, through the sixties, the share of total farm expenditures on petroleum products declined but with the sizeable increase in energy prices during the seventies, this trend has been reversed. The functional relationship hypothesized for this variable is:

$$KOIL = f(RPO, STK, AFS, KPESTA) \tag{3.2}$$

where:

KOIL : The dependant variable defined as farmers' expenditures on gasoline, diesel fuel, oil and lubricants in constant dollars (1971). The deflator is the price index of agricultural petroleum products.

Source: Cansim, Matrix No. 216, 217, 229, 230, 231, 232, 233, 234, 235, 238, 2869, 2879.

RPO : Real price of petroleum products is the price index of petroleum products divided by the GNE-implicit price index. Theoretically, a negative sign would be expected for the parameter of this variable since, as real price of a product goes up, its quantity demanded should go down. However, one should keep in mind that no close substitutes exist for petroleum products once investment in farm machinery has taken place. Therefore, an increase in the price of this necessary input might not reduce useage.

Source: Cansim Matrix No. 2879.

Bank of Canada Review.

STK : The current working stock of machinery is the sum of the previous fifteen years of annual investment in constant dollars plus the current year investment. (see MSR definition below for a more complete discussion of the stock definition). One would expect this variable to be positively correlated with energy consumption since a larger stock of machinery implies more energy consumption. However, this reasoning fails to account for improvements in technology as larger equipment is more energy efficient. Also, most tractors have switched to diesel from gasoline which is less expensive. Both the increase in efficiency and the switch to a less costly fuel could contribute to a decrease in real energy expenditures.

Source: Cansim Matrix No. 862, 2879.

Statistics Canada Cat. No. 62-004.

AFS : Average farm size is defined as total improved land per farm. As average farm size increases, the average energy consumption is expected to increase as labor is replaced by capital when smaller farming units are consolidated.

Source: Statistics Canada, Census of Canada.

KPESTA: Farmers' expenditures per acre on pesticides in constant dollars was defined previously. This variable reflects a change in the production process during the last fifteen years. Using chemicals reduces the need for mechanical operations and hence, energy consumption might decrease. On the other hand, pesticide utilization has been widely adopted during the period under investigation and more field operations at the aggregate level may have increased the demand for petroleum products.

Source: Cansim Matrix No. 216, 217, 229, 230, 231, 232, 233, 234, 235, 238.
Statistics Canada Cat. No. 21-003.

Demand for farm machinery

Although the explanatory variables are somewhat different from previous studies, the same Nerlove adjustment model is used(9). This model is specially designed for forecasting purposes and particular attention is given to the specification of the variables in order to obtain the correct turning points during simulation.

The hypothesized model is expressed as:

$$KMACH = f(MSR(-1), AGE, REV(-1), KMACH(-1)) \tag{3.3}$$

where the variables are defined and rationalized as follows:

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(9)See Appendix A for the derivation of this type of model.

KMACH : The dependant variable which is defined as annual value of purchases of farm implements and equipment at wholesale prices. Annual purchases are for the calendar year or the financial year ending at any time between April 1st and March 31st the following year.(see Statistics Canada Cat. No. 63-203 for more details). This value was deflated by the farm machinery price index, 1971 = 100.

Source: Cansim Matrix No. 862, 2879.

MSR(-1) : Maintenance-stock ratio lagged one period.

> One aspect of durable asset decision making concerns the maintenance of the asset. As acquisition prices for new durable assets increase, it may become more economical to increase maintenance on currently owned durable assets. (Baquet pp. i).

This quote from A.E. Baquet underscores the trade-off between investing in new machinery or repairing the existing stock. On the other hand, using the lagged value, it can be argued that in order to avoid time losses, farmers would repair their machines if possible but would be inclined to invest in new machinery the following year. Therefore, it seems difficult to predict which effect would dominate at the aggregate level.

The maintenance-stock ratio is defined as being the sales of repair parts in constant dollars (1971) divided by the stock of farm machinery on farm. The time period when sales of repair parts occured is the same as the one mentioned for KMACH. The deflator used is the price index for farm machinery since no index is available for repair parts prior to 1971. The stock is defined as being the summation of annual investment in farm machinery over the last fifteen years in constant 1971 dollars. This definition implies a "one-hoss-shay" depreciation pattern where a machine remains the same during its useful life and is obsolete at the end of fifteen years. This definition of stock is preferable to the definition given by Statistics Canada of "current market value of farm implement and machinery" (see Cat. No. 63-203). Penson, Hughes and Nelson showed that the real value of a machine should be calculated using engineering data and the depreciation pattern showed by these data is closer to the "one-hoss-shay" pattern than the geometric or arithmetic function used in declining balance or straight line depreciation procedure. Using depreciation relationships derived from engineering data would have been ideal but they vary between implements and therefore are not applicable for an aggregate capital stock.

Source: Cansim, Matrix No. 862, 2879.

AGE : This variable reflects the age distribution of the existing stock of farm machinery. A higher level of investment is expected for a particular year if the stock is older. It is defined as the proportion of the stock older than three years.

Source: Cansim, Matrix No. 862, 2879.

REV(-1) : One of the most important factors affecting the decision to invest is the availability of capital. The average level of investable funds per farm is defined as annual cash receipts minus farm operating expenditures in constant dollars (1971). This "cashflow"(10) variable was deflated by the price index for gross private business products. A per farm basis has been retained instead of aggregate "cashflow" because aggregate "cashflow" may not vary over time but with a decrease in the number of farms and assuming a marginal propensity to consume less

----

(10)The term cashflow is within quotes because it is not an actual cashflow since consideration for principal repayment has not been taken into account.

than one, each farmer controlls more investable funds and is likely to be more inclined to invest.

Of course, this definition is not the best. An ideal variable would include the increasing value of farm assets, especially the accumulation of more liquid financial assets, and would not include the amount dedicated to principal repayment. However, data limitation prevents the use of such a variable.

Source: Cansim, Matrix No. 159, 162, 163, 164, 165, 166, 167, 168, 169, 170,216, 217, 229, 230, 231, 232, 233, 234, 235, 238, 529.

Statistics Canada, Census of Canada.

KMACH(-1): The lagged value of the dependant variable was defined previously. The coefficient of this variable allows the derivation of the speed of adjustment of the optimum level of investment.(see Appendix A). Indeed, the associated parameter is by definition (1-k), according to the Nerlove adjustment process, where (k) is the coefficient of adjustment.

Demand for repair parts

Expenditures on repair parts are linked to the stock of existing machinery and for this reason, the demand for repair parts is estimated as a ratio. This ratio of repair parts to total stock of machinery is refered to hereafter as the maintenance-stock ratio. The hypothesized function is expressed as:

$$MSR = f(AGE, USE, CASH) \tag{3.4}$$

where:

MSR : The dependant variable defined as expenditures on repairs in constant dollars (1971) divided by the stock of machinery on farms. The definition of this variable has been given previously.
Source: Cansim, Matrix No. 862, 2879.

AGE : This variable has also been defined previously and consists of the share of the stock older than three years. The higher the relative age of the stock, the higher the maintenance-stock expected.
Source: Cansim, Matrix No. 862, 2879.

USE : This variable reflects the relative use of a given stock and is defined as the ratio of energy consumption, i.e. expenditures on gasoline, diesel fuel, oil and lubricant in constant 1971 dollars to the stock of machinery plus the current year purchases of farm machinery. Therefore, the higher the utilization rate, the greater the probability of breakdown in machinery and hence, the higher the expected need of repair parts for a given stock.

Source: Cansim, Matrix No. 216, 217, 229, 230, 231, 232, 233, 234, 235, 238, 2869, 2879.

CASH: This variable is defined as farm cash receipts minus farm operating expenditures on a per farm basis where expenditures on repairs have not yet been taken into account. The nominal values are deflated by the price deflator for gross private business products.

Source: Cansim, Matrix No. 159, 162, 163, 164, 165, 166, 167, 168, 169, 170, 216, 217, 229, 230, 231, 232, 233, 234, 235, 238, 529.

The recursive system

The preceding portion of this chapter presented the hypothesized relationships between the four inputs and their respective explanatory variables. Interrelationships exist

MODEL: INPUTS

THE RECURSIVE SYSTEM OF THE DEMAND FOR DIFFERENT INPUTS I.E.
PESTICIDES, ENERGY, FARM MACHINERY AND REPAIR PARTS FOR FARM MACHINERY.

SYMBOL DECLARATIONS

ENDOGENOUS:
AGE KMACH KOIL KPEST KPESTA MACH MSR OIL PEST REP STK USE

EXOGENOUS:
AFS AREA CASH DUM PIMACH PIOIL PIPEST REV REVCR RPC RPO TIME

COEFFICIENT:
A0 A1 A2 A3 A4 A5 B0 B1 B2 B3 B4 C0 C1 C2 C3 C4 D0 D1 D2
D3

EQUATIONS

```
 1:   KPEST = A0+A1*RPC+A2*REVCR(-1)+A3*DUM+A4*TIME+A5*KPEST(-1)

 2:   KOIL = B0+B1*RPO+B2*STK+B3*AFS+B4*KPESTA

 3:   KMACH = C0+C1*MSR(-1)+C2*AGE+C3*REV(-1)+C4*KMACH(-1)

 4:   MSR = D0+D1*AGE+D2*USE+D3*CASH

 5:   KPESTA = KPEST/AREA

 6:   STK = SUM(I = -15 TO 0 : KMACH)

 7:   AGE = SUM(I = -15 TO -4 : KMACH)/SUM(J = -15 TO -1 : KMACH)

 8:   USE = KOIL/STK

 9:   PEST = KPEST*PIPEST

10:   OIL = KOIL*PIOIL

11:   MACH = KMACH*PIMACH

12:   REP = MSR*(STK-KMACH)*PIMACH
```

TROLL COMMAND: .

among these input demand functions and the complete recursive system is presented on the previous page.

The first four equations are the functional relationships defined previously while the last four equations are identities.

Equation 1 has all the explanatory variables exogenous to the system. The method used to estimate these exogenous variables for forcasting purposes is defined in the next chapter.

Equation 2, the petroleum products function, has, as one of its explanatory variables, a transformation of the endogenous variable of equation 1 which is defined by equation 5. KPESTA is actually the demand for pesticides in constant dollars (1971) on a per acre basis where AREA is defined as total acres under crops. The variable STK is also determined by the system and the summation over (t-15) to (t) of annual investments in farm machinery is given by equation 6.

Equation 3, the farm machinery demand function, also includes MSR and AGE which are determined within the system. The AGE variable is defined as the summation of annual investment in constant dollars over (t-15) to (t-4) divided by the stock of machinery at the beginning of the year. This definition is expressed by equation 7.

Equation 4 which reflects the demand for repair parts and in an indirect way, is also a function of two variables defined by the system; AGE and USE. AGE has just been defined above and USE, which reflects the degree of utilization of the stock of machinery, is given by equation 8. KOIL comes from equation 2 and STK from equation 6 which itself comes from equation 3.

The set of equations 9 through 12 merely states the necessary transformations the estimated variables must undergo to be converted back to nominal values. These current dollar values involve only the multiplication of the constant values by their respective price index. Equation 12 also shows the transformation of the maintenance-stock ratio back to the demand for repair parts (REP) which is the variable of interest.

CHAPTER FOUR

EMPIRICAL RESULTS

Introduction

The empirical results for the models specified are presented in this Chapter for Canada, Eastern and Western Canada. The provinces included into Eastern Canada are the Maritimes, Quebec and Ontario. The prairie provinces as well as British Columbia are embodied into Western Canada. The time period investigated is from 1962 to 1977. This rather short period of time has been chosen because the price deflators employed, (1971=100.), are not available prior to 1961 and any attempt to transform the 1935-39 price indexes failed to derive consistant results since the weights and components used in these indexes are radically different than the ones used in 1971. As it has been mentioned in the model specification, most of the data are from Cansim as they appeared on July 1st,1979.

All equations have been estimated in both linear and log-linear form and tested for autocorrelation. One of the consequences of autocorrelated errors is that

> the predictions based on ordinary least squares estimates will be inefficient, in the sense that they will have a larger variance as compared with predictions based on other estimates obtained from

other econometric techniques. (Koutsoyiannis, pp. 211)

Since one of the main objectives of this study is forecasting, whenever autocorrelation appeared, it was corrected according to the procedure utilized within the TROLL econometric package(11), which is similar to a two-stage Cochrane-Orcutt method.

The first part of this chapter deals with each input demand equation separately and each case can be divided into four subsections. First, the behaviour of actual demand of the input considered is shown and compared subjectively to the explanatory variables. Second, the equation parameters are discussed and compared between Eastern and Western Canada in order to see the relative impact of each of the hypothesized explanatory variables. Similitudes and differences are pointed out whereas results for Canada serve mainly as a comparison basis. Third, the estimated input demand (O.L.S.) and simulated ones are compared to the actual performance over time of the input considered. An analysis of how well the O.L.S. and simulated estimates performed is provided also. Finally, a discussion of the alternative variables and specifications follows the analysis of each input demand relationship. Such discussion is felt to be relevant for further extensions and

(11)The TROLL system has been developped initially at M.I.T. and then at the National Bureau of Economic Research. See TROLL, A User's manual, NBER Computer Research Center, Cambridge, Mass..

improvements of the proposed models.

The second part of the chapter is dedicated to testing the predicting power of the proposed models by comparing forecasted values to actual ones for 1978. Forecasted estimates are also provided and discussed for the years 1979 and 1980.

Estimation of structural equations

Pesticides

Demand for pesticides.

Real sales of pesticides more than doubled in Canada between 1962 and 1968 (See Chart 4.1). Sales moved from 28 million to 57 million in constant dollars (1971). It decreased however during 1969 and 1970 by 25% and then started to increased again until 1973 to reach a level of $77 million. Another two-year period of declining sales took place in 1974 and 1975 but the decrease was relatively less important (13%) than between 1968 and 1970. Therefore, even with two cycles which peaked in 1968 and 1973, Canadian demand has been generally increasing over time and reached a level of $80 million in 1977.

The behaviour of Canadian demand described above is, of course, that of both Eastern and Western demands combined.

CHART 4.1:

DEMAND FOR PESTICIDES BY REGIONS.
('00,000 OF 1971 DOLLARS)

```
  100.           300.           500.           700.           900.
     |==============|==============|==============|==============|
1962 |  B C          A
     |   BC           A
     |   C B          A
     |    C B           A
     |        C B               A
1967 |          C B                 A
     |            C  B                   A
     |        C    B               A
     |     C     B            A
     |      C   B              A
1972 |         C    B                 A
     |                  C     B                          A
     |                 B C                         A
     |              B     C                      A
     |               B          C                      A
1977 |               B              C                       A
     |==============|==============|==============|==============|
  100.           300.           500.           700.           900.
```

**************************LEGEND****************************

TIME BOUNDS: 1962 TO 1977

SYMBOL	SCALE	NAME
A	#1	KPESTCAN
B	#1	KPESTEST
C	#1	KPESTWST

****

NOTA

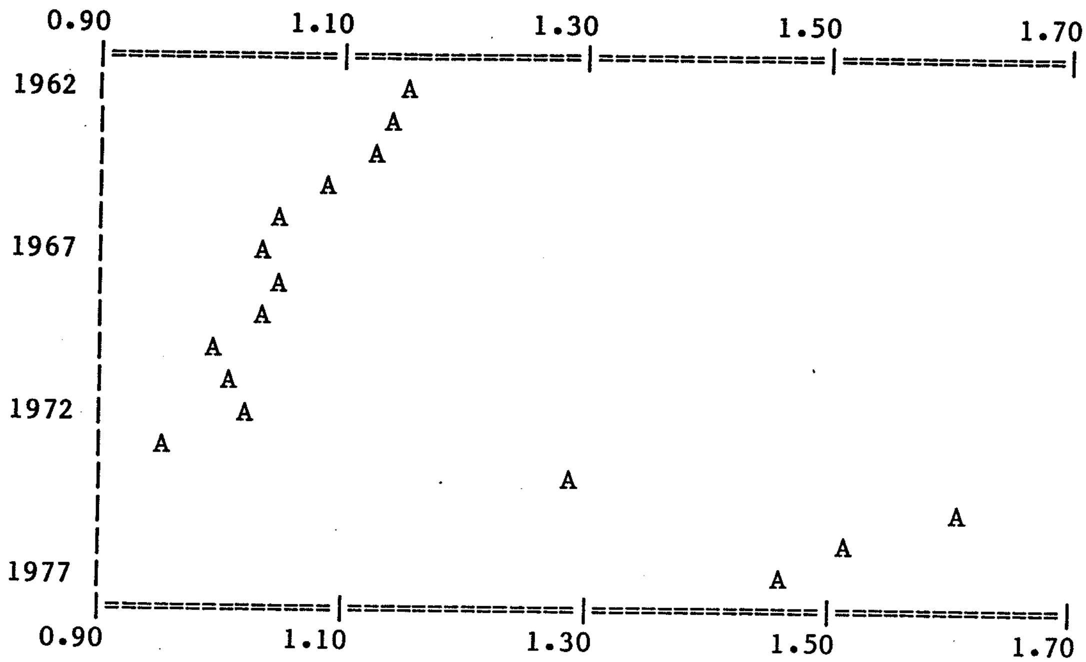
SYMBOLS A, B AND C REFLECT CANADA, EAST AND WEST RESPECTIVELY.
TROLL COMMAND: .

However, regional demands did not behave similarly throughout the period under investigation as shown in Chart 4.1. Real demand for pesticides in Western Canada has been continually increasing since 1964 until 1977 except for the period 1969 to 1972 where it fell short of the time trend. This trend upward in pesticides utilization has certainly been stimulated by a generally decreasing real price of chemicals throughout the sixties until 1973. (See Chart 4.2). Between 1973 and 1975, even though real price of pesticides increased by 70%, the quantity demanded still rose by 8%. Real price of pesticides fell by 10% between 1975 and 1977, and quantity demanded rose 35%. The impact of the large increment in prices seems to have contributed to keeping the quantity demanded from increasing. When an increase in the real price of a product does not reduce the quantity demanded, it certainly means that at the aggregate level, marginal revenues from its utilization are much greater than its marginal costs and the optimal level of utilization is still not reached.

As to the decrease in the quantity demanded for the period 1969 to 1972, it can be explained by an increase in grain inventories in the late sixties which drove prices down and hence, farmers' revenues decreased. Chart 4.3 reproduces farmers' revenues per acre (REVCR). Western revenues per acre were relatively low for the period 1969-71. Chart 4.3 also shows that REVCRWST decreased by

CHART 4.2:

REAL PRICE INDEX OF AGRICULTURAL PESTICIDES.
(1971 = 1.)



**************************LEGEND*****************************

TIME BOUNDS: 1962 TO 1977

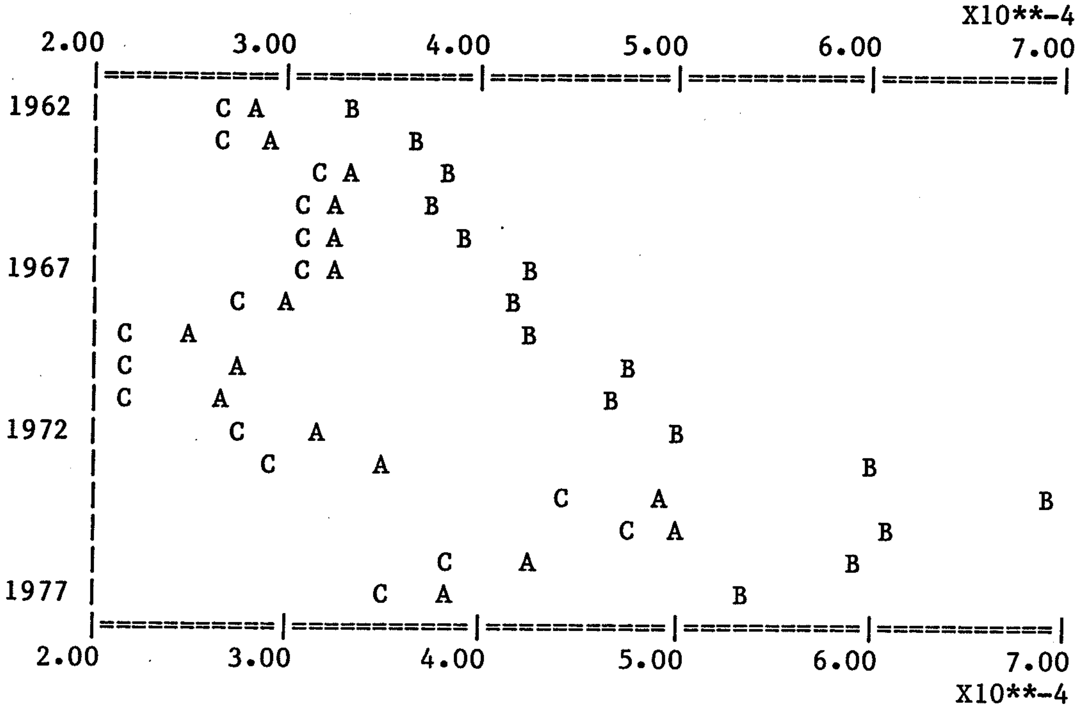
SYMBOL SCALE NAME
A #1 RPC

****

TROLL COMMAND: .

CHART 4.3:

REVENUE FROM CROPS PER ACRE BY REGIONS.
('00,000 OF 1971 DOLLARS)



**************************LEGEND****************************

TIME BOUNDS: 1962 TO 1977

SYMBOL	SCALE	NAME
A	#1	REVCRCAN
B	#1	REVCREST
C	#1	REVCRWST

****

NOTA

SYMBOLS A, B AND C REFLECT CANADA, EAST AND WEST RESPECTIVELY.
TROLL COMMAND: .

about 20% between 1975 and 1976 without any fall in 1977 sales of pesticides. Of course, the fact that the price level was going down did partly offset the revenue effect, still marginal revenues being greater than marginal costs contributed to maintaining the demand for pesticides. Two other factors which contributed to the drop in the quantity demanded during the period 1969-72 can be mentioned. The LIFT program in 1970 caused the number of acres seeded to decrease substantially and hence, the quantity of pesticides demanded decreased also. As there were several thousand extra acres in summerfallow in 1970, weeds were controlled by tillage and less herbicides were necessary during the following year.

Eastern Canada demand followed the same pattern as Western Canada from 1962 to 1973. It is interesting to note however that during this period Eastern demand for pesticides was consistantly greater than Western demand except in 1962 and 1963. Therefore, with a number of acres under crops about three to four times smaller than in the West, Eastern level of pesticide utilization is closer to the optimum level where marginal costs equal marginal revenues and this should be reflected by a higher coefficient of adjustment in empirical estimation. Eastern demand should also be more sensitive to a variation in either the price or the revenue per acre(12). Charts 4.1,

---

(12)This point will be verified in the next section.

4.2 and 4.3 show that the rather low real price of chemicals in 1973 contributed to reach the highest level of pesticides sales but the tremendous increase in the price level in 1974 and 1975 overcame the revenue effect which would have favoured an increase in the demand level. The price effect would have tended to drive up the quantity demanded in 1976 and 1977 while a decrease in demand should have been expected from the revenue effect. Both effects seem to have offset each other and the demand levels remained rather constant from 1975 to 1977.

<u>Structural equations of the demand for pesticides</u>.

The estimated equation takes the following form:

$$KPEST = a0 + a1*RPC + a2*REVCR(-1) + a3*DUM + a4*TIME + (1-k)*KPEST(-1) \qquad (4.1)$$

where "k" is the coefficient of adjustment.

Empirical results are given below in Table 4.1.

Before starting the analysis as such, it should be mentioned that results in Eastern and Western Canada are not quite comparable since the equations are not specified exactly the same way. However, as the two variables added

TABLE 4.1

Estimated parameter values for the demand for Pesticides in Canada, Eastern and Western regions in linear and log-linear form.

Equation[1]	Constant	RPC	REVCR(-1)	DUM	TIME	KPEST(-1)	R^2
Units	(1.0E+9)	(1971=100.)	(1.0E+9)			(1.0E+9)	
Canada							
PCO[2]	-3.77	-3.09	37.50	-138.1	17.90	0.61	.992
	(***)	(***)	(*)	(***)	(***)	(***)	
PCL[2]	-439.03	-0.82	-0.35	-0.01	58.60	0.61	.993
	(***)	(***)	(**)	(***)	(***)	(***)	
East							
PEO[2]	0.02	-3.15	90.50			-0.003	.881
	(***)	(***)	(***)				
PEL[2]	10.19	-0.82	0.86			0.39	.918
	(**)	(***)	(**)			(**)	
West							
PWO[2]	-1.90	-0.75	13.20	-80.6	9.70	0.71	.995
	(***)	(**)		(***)	(***)	(***)	
PWL[2]	-578.12	-0.61	0.22	-0.02	76.70	0.66	.994
	(***)	(***)	(**)	(***)	(***)	(***)	

---

*, **, ***. Significance of the parameters at the 10, 5 and 1 percent level respectively;

1. The first letter of the acronym stands for Pesticides, the second letter for the region; Canada, East or West, the third letter reflects whether the data were in Original (O) or logarithmic (L) form;

2. Results shown have been corrected for autocorrelation using the technique provided by TROLL econometric package which is similar to a two-stage Cochrane-Orcutt method.

in Western Canada (and Canada) reflect specific tendencies which do not appear in Eastern Canada as discussed in the previous chapter, results will still be compared keeping in mind the limitations mentioned above.

Results in Table 4.1 show all parameters have the expected signs and most of them are statistically different from zero at the 5% level or less. Both equation specifications using original data or a logarithmic transformation show relatively high R^2 which vary between 0.88 in Eastern Canada and 0.99 in Western Canada. The marginal price effect appears to be much more important in the East than in the West, especially in the linear equations, where it is more than four times greater. The marginal effect of the revenue variable is also significantly greater in Eastern Canada using both specifications. Therefore, any variation in the real price of pesticides or in the revenue variable would severely affect the estimated demand for pesticides. As the coefficient of the lagged endogenous variable is rather small, much smaller than in Western Canada, the Eastern equation can be expected to be less stable than the Western equation. One of the reasons for a lower R^2 is of course because Eastern demand is function of less explanatory variables than Western demand and variation in the demand level which could be due to other factors are picked up by the price and revenue variables. Hence, the real effect of these variables could be overestimated.

TABLE 4.2

Short run and long run elasticity of the demand for Pesticides with respect to the explanatory variables and adjustment coefficients.

Elasticity[1]\equation	PCO	PCL	PEO	PEL	PWO	PWL
$e^{s}_{kpest.rpc}$	-0.66	-0.82	-1.35	-0.82	-0.33	-0.61
$e^{l}_{kpest.rpc}$	-1.69	-2.10	---	-1.34	-1.14	-1.79
$e^{s}_{kpest.revcr(-1)}$	0.23	0.35	1.55	0.86	0.15	0.22
$e^{l}_{kpest.revcr(-1)}$	0.60	0.90	---	1.41	0.52	0.65
k : O[2]	0.39		---		0.29	
k : L[2]		0.39		0.61		0.34

---

1. s stands for short run elasticity,
   l stands for long run elasticity.

2. k is the coefficient of adjustment and
   O reflects the equation using original data whereas
   L reflects the equation expressed in logarithmic form.

Table 4.2 shows both short and long run elasticities of the demand with respect to the explanatory variables from the logarithmic equation, which are a sort of "average" elasticities through the period under investigation as well as elasticities at the mean from the linear equations. Out of the logarithmic equations, it can be seen that the short run price elasticities vary from -0.8 in Eastern Canada to -0.6 in Western Canada. A 10% increase in the real price level would then be followed by a 8% and 6% decrease in the quantity demanded in the short run and would cause a greater adjustment in the long run decreasing the demand by 13% and 18% in Eastern and Western Canada respectively. But, surprisingly, Canadian demand shows the same short run price elasticity as in Eastern Canada. A possible explanation is that Eastern and Western demand equations are not specified in quite the same way. Consequently, one could expect a price elasticity higher than 82% in Eastern Canada if the two dummy variables were added to the Eastern Canada equation. The price elasticity at the mean from the linear equation also shows a coefficient four times higher in Eastern than in Western Canada. These coefficients strengthen the different levels of response in the East and in the West with respect to the price of pesticides. Canada's coefficient shows a value somewhere between Eastern and Western values.

Lagged revenue from crop sales also has a higher influence on the demand in Eastern than in Western Canada. The short run demand elasticity with respect to the revenue variable from the log-linear equation is about 0.85 in Eastern Canada versus 0.20 in Western Canada and 1.55 versus 0.15 respectively from the linear equations. This difference might be explained by the fact that in Eastern Canada, revenues from crops constitute about 50% to 60% of total revenues versus about 75% in the West. This reflects the higher relative importance of the dairy industry in Eastern Canada. Revenues from crop sales show only a fraction of the benefits procured by pesticides utilization because indirect revenues from milk are not taken into account. A portion of the revenues from milk can be attributed to more pesticides application on hay fields in the form of herbicides and insecticides. Therefore, a part of other revenues might and should be used to purchase pesticides which overestimates the revenue elasticity. Moreover, many Eastern farmers produce special crops such as corn, root crops, fruits and vegetables. These crops require larger applications of herbicides and insecticides. Therefore, especially for these producers, the revenue elasticity of the demand for pesticides will be high. If farmers expect a profitable year, they will expand crop production and use pesticides. If the preceding year crop prices were lower, farmers will not be inclined to expand production. It can be pointed out, however, that in the long run, the increase in the revenue elasticity in the West is more than three times than in the East. This is quite realistic since a continuous trend will most likely have a greater influence where the relative share of revenues coming from crops is higher.

As to the coefficients of adjustment, Eastern Canada shows a short period of adjustment which is not significantly different from one year in equation PEO whereas Western Canada seems to have a longer (3years) adjustment period. Here again, this is consistant with the fact that revenues from crops constitute a larger part of total revenues in the West. Since the number of farmers using pesticides is steadily increasing, it is more difficult, at an aggregate level, to reach an optimum level of pesticide utilization. This longer adjustment coefficient is also consistant with lower coefficients of elasticities, which imply the demand for pesticides is less affected by variations of the explanatory variables and moves more slowly to the optimum level. Furthermore, as mentioned previously, because utilization of pesticides on a per acre basis is more than four times greater in the East, the actual degree of pesticide utilization in the East is certainly closer to the optimal point where marginal costs equal marginal revenues. Hence, the period of adjustment should be shorter in the East.

Historical validation and simulation.

As mentioned previously, the period covered by the regressions is from 1962 to 1977. Tables 1 to 6 and Charts 1 to 3 in Appendix B show the results estimated by O.L.S. and those obtained by simulation for Canada, East and West respectively, in constant 1971 dollars. Table 4.3 gives the standard-error of estimates (SEE) and the percentage of SEE at the mean which are related to estimated expenditures, and both root-mean squares (RMS) and RMS percent error which are related to simulated expenditures.

Generally, both estimated and simulated demands perform better in Western than in Eastern Canada. The RMS in Western Canada is 90% smaller and the RMS percent error is about 50% smaller than in Eastern Canada. With respect to estimated demand, the SEE and the SEE% are about 40% smaller in Western Canada. Within a specific region however, estimated and simulated demand perform alike although simulated demand for Canada seems to perform slightly better than estimated demand.

In both Eastern and Western Canada, the major turning points or variations in actual demand were caught by both estimated and simulated demand as shown clearly in Charts 2 and 3, Appendix B. The only major exception was for the period 1968 to 1971 in Eastern Canada where the actual

TABLE 4.3

Standard error of estimates (SEE) and percentage of SEE at the mean, root mean squares (RMS) and RMS percent error related to the demand for Pesticides in Canada, Eastern and Western regions.

Equation[1]	SEE	SEE% mean	RMS	RMS%
Canada				
PCL	31.74[2]	5.91	21.73	4.46
East				
PEL	28.22[2]	10.47	31.59	10.86
West				
PWO	20.41	7.62	16.56	7.38

1. The equations retained were those which showed the best performances in term of R^2, t-values of the parameters and SEE.

2. As these equations were estimated in logarithms, the SEE varies with the quantity demanded and the values presented above are calculated at the mean.

demand level decreased but both estimation and simulation procedures showed a continual increase throughout the period.

Related material.

As mentioned at the beginning of the chapter, a short discussion of alternate variables and variable specifications that have been attempted will be presented after the analysis of each different input demand equation. Doing so should contribute to further research in the area, as well as defending the selection of particular explanatory variables.

For the pesticide demand equation, had goodness of fit of the equation been the only criterion for equation selection, a regression of TIME alone would have been almost as good as the ones presented above. Throughout the sixties and seventies, there has been a continuous increase in the use of pesticides. However, it is obvious that a trend over sixteen years is not an explanatory variable. The underlying basis for this trend is required if the pattern is to be explained.

Different deflators were used to obtain the real price of chemicals. Some of the deflators employed were; the agricultural general input price index, the consumer price index and the output price index. All of them were found to be less statistically significant than the gross national expenditures implicit price index. It might be argued that, theoretically, the output price index should have been retained particularly since short term production factors are strongly influenced by the expected price of output. However, this deflator was not retained since this type of index is a Laspeyres' weighted price index and does not take into account the effects of demand and supply on prices. As agricultural output prices are widely affected by demand and supply conditions of the market, this index of output varies widely without really reflecting the purchasing potential of farmers. These wide fluctuations can cause the price effect to be insignificant when it really is significant and vice versa. The CPI was not retained either since the basis of comparison is too different. That is, the CPI reflects only a specific category of goods when the "real" price of chemicals needs to be compared to the general price level in the economy, which is better reflected in the GNE-implicit price index. Another advantage of choosing the GNE-implicit price index is because it is forecasted by other macro econometric models and their results could be used to improve the predictive power of the present model.

The following specifications were employed with the revenue variable; aggregate revenues from crops, revenues from crops on a per farm basis and on a per acre basis. Revenues from crops on a per acre basis performed better statistically but, this variable was primarely retained because it appears to be the best theoretical one. Indeed, aggregate revenues as such do not mean much at the micro level where decisions are made. Revenue per farm for instance is more appropriate but according to rational decision making, revenue from crops per acre had to be retained.

With respect to the equation specification in Eastern Canada, dummy variables were also tried. However, when a trend variable was added, it appeared to be insignificant and caused the coefficient of the lagged dependant variable to become negative. In this type of model, it implies an adjustment coefficient greater than one which makes no sense. When both dummy variables (TIME and DUM) were added for comparison purposes, the price elasticity was not greater than 0.82 as it was expected and the revenue variable showed the wrong expected sign. Therefore, the specification without dummy variables was retained.

Petroleum products

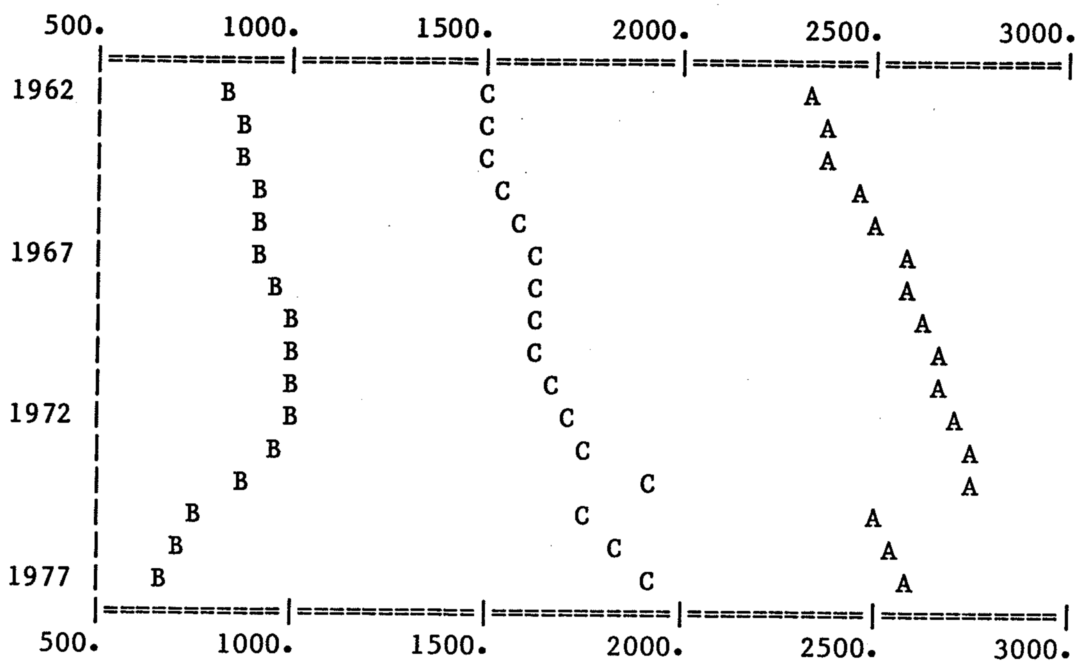
Demand for petroleum products.

As it is shown in Chart 4.4, the behaviour of real demand for petroleum products continually increased until 1972, in both Eastern and Western Canada. The quantity demanded continued to increase in the West after 1972 at about the same rate. However, in Eastern Canada the quantity demanded decreased constantly since 1973. As shown in Chart 4.5, the real price of petroleum products generally decreased in Eastern Canada until 1973. It has increased at a very high rate since then and the price effect could have had a dampening effect on use. However, the price level followed the same pattern in Western Canada without any noticeable effects on demand.

The working stock of farm machinery in Western Canada was almost constant until 1968 (see Chart 4.6) and after a slight decline in 1969, it continually increased througout the remaining years under consideration. As petroleum products consumption increased each year during the period, it can be assumed that farmers had the potential to accomplish more work during the sixties with the given stock of farm machinery. This could be interpreted as a sign of overcapitalization in equipment. The high increase in the stock of farm machinery which occurred in the seventies was

CHART 4.4:

DEMAND FOR PETROLEUM PRODUCTS BY REGIONS.
('00,000 OF 1971 DOLLARS)




```
**************************LEGEND****************************

TIME BOUNDS: 1962 TO 1977

SYMBOL SCALE NAME
   A     #1   KOILCAN
   B     #1   KOILEST
   C     #1   KOILWST

************************************************************
```

NOTA

SYMBOLS A, B AND C REFLECT CANADA, EAST AND WEST RESPECTIVELY.
TROLL COMMAND: .

CHART 4.5:

REAL PRICE INDEX OF PETROLEUM PRODUCTS BY REGIONS.
(1971 = 1.)

```
0.900   0.950   1.000   1.050   1.100   1.150   1.200   1.250
     |=======|=======|=======|=======|=======|=======|=======|
1962 |                                 B        A    C
     |                          B           A     C
     |                             B       A   C
     |                        B    A  C
     |                        2B
1967 |                     2B
     |                     B  A C
     |                  B  A C
     |              B 2
     |                3
1972 |        B A C
     |     BAC
     |C     A        B
     |             C    A        B
     |                      C    A     B
1977 |                         C    A      B
     |=======|=======|=======|=======|=======|=======|=======|
0.900   0.950   1.000   1.050   1.100   1.150   1.200   1.250
```

************************LEGEND*************************

TIME BOUNDS: 1962 TO 1977

SYMBOL	SCALE	NAME
A	#1	RPOCAN
B	#1	RPOEST
C	#1	RPOWST

****

NOTA

SYMBOLS A, B AND C REFLECT CANADA, EAST AND WEST RESPECTIVELY.
TROLL COMMAND: .

CHART 4.6:

WORKING STOCK OF CAPITAL BY REGIONS.
('00,000,000 OF 1971 DOLLARS)

```
     20.0      30.0      40.0      50.0      60.0      70.0      80.0
      |=========|=========|=========|=========|=========|=========|
1962 |B             C                    A
     |B             C                    A
     |B             C                    A
     |B             C                    A
     |B             C                    A
1967 |B             C                    A
     |B             C                   A
     | B          C                     A
     | B          C                     A
     | B           C                    A
1972 |  B          C                     A
     |   B           C                      A
     |    B            C                        A
     |      B             C                         A
     |       B               C                          A
1977 |         B                C                           A
     |=========|=========|=========|=========|=========|=========|
    20.0      30.0      40.0      50.0      60.0      70.0      80.0
```

**************************LEGEND*****************************

TIME BOUNDS: 1962 TO 1977

```
SYMBOL SCALE NAME
   A    #1   STKCAN
   B    #1   STKEST
   C    #1   STKWST
```

****

NOTA

SYMBOLS A, B AND C REFLECT CANADA, EAST AND WEST RESPECTIVELY.
TROLL COMMAND: .

much greater than the increase in energy consumption and it can be assumed that farmers are still overcapitalized. Surprisingly, the working stock of capital which was constant in the East until 1971 (see Chart 4.6) started to increase regularly in 1972 with a constant decrease in energy consumption. The price increase certainly had a dampening effect on the demand for petroleum products as mentioned above but the two opposite behaviours of an increase in farm machinery demand and a decrease in petroleum products demand, could induce the belief that Eastern farmers are exorbitantly overcapitalized. However, a tentative explanation for the decreasing sales of petroleum products is the greater utilization of diesel tractors(13). Since diesel fuel is less expensive, the decrease in expenditures is due to the price, not to the quantity of energy utilized.

From another source however, (see Table 4.4) it appears that sales of diesel fuel in Eastern Canada did increase significantly since 1972 but sales of gasoline did not fall as hypothesized. Therefore, according to this latter source, sales in constant dollars should have increased.

Which source is more reliable...?

----

(13) It would have been very interesting to look at the rate of change of diesel type tractors to gasoline type but the data available do not make this distinction prior to 1974.

TABLE 4.4

Sales of motor gasoline and diesel fuel[1].

Type of fuel.	Eastern Canada	Western Canada
Gasoline.		
1969	7,050	10,513
1970	7,088	11,227
1971	6,686	11,768
1972	6,734	12,094
1973	6,963	12,539
1974	6,908	12,391
1975	7,903	13,021
1976	7,219	13,327
1977	6,613	13,887
Diesel fuel.		
1969	1,952	4,183
1970	1,340	4,366
1971	1,641	4,444
1972	1,824	4,668
1973	2,042	5,039
1974	2,411	5,292
1975	2,808	5,846
1976	2,908	6,533
1977	2,975	6,701

1. Thousand barrels of 35 Canadian gallons.

Source: Refined Petroleum Products. (catalogue no 45:208)

Statistical tables published in "Refined Petroleum Products" (Statistics Canada Cat. No. 45-208) are

> using information obtained from surveying establishments primarily engaged in refining crude petroleum and in wholesaling refined petroleum products.

Sales to farmers are defined as follows:

> Includes only those sales made to farm consumers. Includes an authoritative estimate of such sales of the respondant's jobbers, resellers, agent, etc... who are not themselves respondants. As there is a large number of such operations, every effort is made by the respondent to allocate such sales and avoid their inclusion below in 8,"Unclassified".

The statistical tables published in "Farm Net Income" (Statistics Canada Cat. No. 21-202) are the ones used in the present study and expenditures on petroleum products have been taken from farm surveys since 1971. However, expenditure data published in "Farm Net Income" do not include the Federal excise tax of $0.10 per gallon purchased since June 25th, 1975 on gasoline and any of the provincial subsidies on both gasoline and diesel fuel.

The method by which the former source determined fuel use by agriculture is not a statistically sound one. The accounting procedure lacks precision because the "authoritative" source is a judgement rather than an exact measurement. The latter source is biased since farmers declare their actual expenditures before the federal tax rebate and data are therefore not consistant over time. Also, if the relative provincial taxes varied over time(14), there is no consistancy either. Furthermore, the price deflator is overestimated due to these provincial subsidies and hence, expenditures are underestimated.

<u>Structural equations of the demand for petroleum products</u>.

The estimated demand for gasoline, diesel fuel, oil and lubricants is assumed to take the following form:

$$KOIL = a0 + a1*RPO + a2*STK + a3*AFS + a4*KPESTA \qquad (4.2)$$

Results for Eastern, Western and Canada are summarized in Table 4.5.

Generally, both equation specifications perform rather well in all regions with R^2 varying from 0.98 in equation PPEO to 0.99 in equation PPWL. All parameters are statistically significant except for AFS in Eastern Canada. Table 4.6 shows the elasticities which will be referred to in the following discussion.

----

(14)Time limitation prevent the verification of such hypothesis.

TABLE 4.5

Estimated parameter values for the demand for petroleum products in Canada, Eastern and Western regions in linear and log-linear form,

Equation[1]	Constant	RPO	STK	AFS	KPESTA	R^2
Units	(1.0E+9)	(1971=100.)	(1.0E+9)	(1.0E+6)	(1.0E+12)	
Canada						
PPCO[2]	0.32	-5.32	-1.68	2.31	2.51	.995
	(***)	(***)	(***)	(***)	(***)	
PPCL[2]	10.18	-0.29	-0.32	0.21	0.06	.995
	(***)	(***)	(***)	(***)	(***)	
East						
PPEO[2]	0.24	-9.71	-2.59	0.85	0.17	.979
	(***)	(***)	(***)		(***)	
PPEL[2]	10.21	-1.11	-0.84	0.17	0.03	.984
	(***)	(***)	(***)		(*)	
West						
PPWO[2]	0.17	-6.06	0.27	6.22	3.46	.998
	(***)	(***)		(***)	(***)	
PPWL[2]	8.18	-0.35	0.13	0.22	0.08	.999
	(***)	(***)	(***)	(***)	(***)	

---

*, **, ***. Significance of the parameters at the 10, 5 and 1 percent level respectively;

1. The first two letters of the acronym stand for Petroleum Products, the third letter for the region; Canada, East or West, the fourth letter reflects whether the data were in Original (O) or logarithmic (L) form;

2. Results shown have been corrected for autocorrelation using the technique provided by TROLL econometric package which is similar to a two-stage Cochrane-Orcull method.

TABLE 4.6

Short run elasticity of the demand for Petroleum Products with respect to the explanatory variables.

Elasticity[1]\equation	PPCO	PPCL	PPEO	PPEL	PPWO	PPWL
$e^{s}_{koil.rpo}$	-0.22	-0.29	-1.13	-1.11	-0.38	-0.35
$e^{s}_{koil.stk}$	-0.39	-0.32	-0.64	-0.84	0.06	0.13
$e^{s}_{koil.afs}$	0.25	0.21	0.10	0.17	0.16	0.22
$e^{s}_{koil.kpesta}$	0.08	0.06	0.04	0.03	0.11	0.08

1. s stands for short run elasticity.

Given the specification of this equation, the long run elasticities are not available.

At first glance, both linear and log-linear specifications appear comparable. In any case, the same relationships are found between East and West and the differences are of degree, not of type or general trend. In all equations, the price variable is always significant with the expected sign but its value differs considerably between East and West. Eastern Canada shows a price elasticity much higher than Western Canada with a value of about 1.1 versus 0.4 in Western Canada. A possible explanation would be that Western farmers use machinery more intensively and do not reduce fuel consumption whatever the price increases since no close substitutes are available. On the other hand, Eastern farmers, with smaller farms, were likely not employing the latest technology when the price of energy started to escalate in the seventies. It is possible that at this time, farmers adopted newer, more energy efficient machines, trading in old gasoline tractors for new diesel ones, given the price of diesel fuel is lower than gasoline.

The parameters of the other explanatory variables do not invalidate the above hypothesis. Indeed, the parameter of the working stock of machinery shows a negative sign in Eastern Canada, (although elasticity values of -0.6 or -0.8 might appear a little high) and a positive sign with a small value in Western Canada. Therefore, adopting newer technology in Eastern Canada would have contributed to energy efficiency whereas in Western Canada, an increase in the stock causes a slight increase in petroleum products sales.

Average farm size, while not significant in the East, does have an impact in the West. This strengthens the assumption made in the previous chapter, that small and inefficient farms are being taken over by more efficient farmers. These latter have to make more use of machinery to improve their return from the land which, of course, increases petroleum products consumption.

The last variable in the demand for petroleum products equation, expenditures on pesticides per acre (KPESTA), was introduced to reflect the change in crop production; using chemicals to control weeds rather than tillage. Its coefficient does not have a large value but is statistically quite significant. As the sign turns out to be positive, it indicates that wider utilization of pesticides and other chemicals requires more energy consumption and overcomes the energy saving of reduced tillage.

For Canada, the results are relatively similar to Western Canada, except for the parameter on the working stock of capital. As shown in Chart 4.4, the large decrease in petroleum products expenditures in Eastern Canada overcame the increasing pattern in Western Canada and caused the Canadian stock parameter to be negative.

<u>Historical validation and simulation</u>.

Tables 7 to 12 and Charts 4 to 6 in Appendix B refer to estimated and simulated demand for petroleum products in the East, the West and all Canada.

Even with the data problems discussed previously, it is interesting to note that estimated and simulated demands perform very well in both regions as well as in Canada. Percentage of errors provided for each year are all lower than 5% whatever the region and most of the time they are quite close to zero. As to the turning points, Chart 5 in Appendix B shows that, in Eastern Canada, the only major turning point which occurred in 1973 was adequately picked up by both estimation and simulation procedures. In Western Canada, Chart 6 in Appendix B shows that both estimated and simulated quantity demanded for petroleum products followed the actual values very closely until 1973. Between 1974 and 1975, a 8% decrease in sales occurred. The amplitude was not predicted by O.L.S. nor by simulation procedure. Though, they both predicted a small 2% decrease between these two years. However, even though 1974, 1975 and 1977 were not quite predicted by both methods, the percentage of error was only about 4%.

Another way to verify the performance of estimated and simulated demand is to look at the relevant statistics

TABLE 4.7

Standard error of estimates (SEE) and percentage of SEE at the mean, root mean squares (RMS) and RMS percent error related to the demand for Petroleum Products in Canada, Eastern and Western regions.

Equation[1]	SEE	$SEE\%_{mean}$	RMS	RMS%
Canada				
PPCO	24.53	0.96	43.21	1.70
East				
PPEL	7.10[2]	0.79	17.33	1.93
West				
PPWL	13.80[2]	0.83	33.91	1.87

1. The equations retained were those which showed the best performances in term of R^2, t-values of the parameters and SEE.

2. As these equations were estimated in logarithms, the SEE varies with the quantity demanded and the values presented above are calculated at the mean.

summarized in Table 4.7. The RMS percent error appears to be smaller than 2% in all equations and the SEE% is even smaller than 1% in all equations.

If estimated demand seems to perform slightly better than simulated demand in a specific region, it cannot be stated that either one of the procedures employed performs better in one region than in another since both regional SEE% are practically equivalent, and so are both RMS percent error.

Related material.

Due to the "special" behaviour for Eastern demand of petroleum products, this equation was rather difficult to evaluate. As a first attempt, the explanatory variables were the price index of petroleum products, the working stock of machinery and the number of acres under crops.(AREA). This specification showed a poor goodness of fit and negative parameters for both STK and AREA. However, it should be noted that due to data problems, particular attention should be given to this equation for policy making or forecasting purposes. A more sophisticated analysis should be done at a disaggregated level in order to render the predictions more reliable. Even if the RMS percent error and the SEE% are very low, due to the wrong theoretical expected sign of the STK variable in the East, forecasts using this specific equation could be quite erroneous under some conditions.

Farm machinery

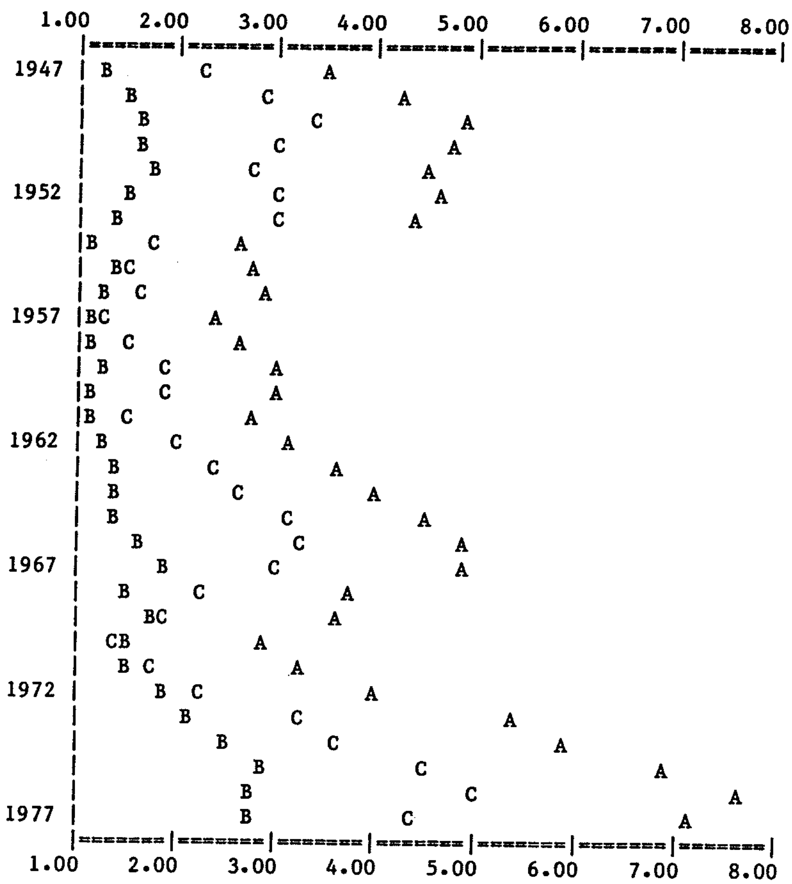
Demand for farm machinery.

The surge in farm machinery purchases in Canada between 1948 and 1953 was followed by two major increases during the periods 1963 to 1967 and 1973 to 1977 (see Chart 4.7). A fifteen year interval elapsed between the earlier peak investment levels while the duration of the more recent cycle is ten years. It could be underlined that the first two peak investment levels i.e. from 1948 to 1953 and 1963 to 1967, were both between \$400 and \$500 million.

Chart 4.7 also shows that the annual farm machinery investment cycles are similar in Eastern and Western Canada although Western cycle is considerably greater. For instance, Western expenditures increased by more than 100% from \$155 million to \$321 million between 1961 and 1966 whereas Eastern expenditures increased by 60% between 1961 and 1967. By 1970, Western expenditures on farm machinery had decreased by 56% down to \$141 million only but they increased again by 250% by 1976. Eastern expenditures

CHART 4.7:

DEMAND FOR FARM MACHINERY BY REGIONS.
('00,000,000 OF 1971 DOLLARS)



************************LEGEND**************************

TIME BOUNDS: 1947 TO 1977

SYMBOL	SCALE	NAME
A	#1	KMACHCAN
B	#1	KMACHEST
C	#1	KMACHWST

****

NOTA

SYMBOLS A, B AND C REFLECT CANADA, EAST AND WEST RESPECTIVELY.
TROLL COMMAND: .

CHART 4.8:

PERCENTAGE OF THE FARM MACHINERY STOCK OLDER THAN
THREE YEARS BY REGIONS.

```
 0.675   0.700   0.725   0.750   0.775   0.800   0.825   0.850
     |=======|=======|=======|=======|=======|=======|=======|
1962 |                                               B A  C
     |                                              B A C
     |                                           BAC
     |                                C  A   B
     |                     C    A       B
1967 |              C     A        B
     |           C   A       B
     |                 C A  B
     |                       B    A C
     |                             B          A     C
1972 |                               B            A      C
     |                                B          A     C
     |                          B     A  C
     |                B    AC
     |         BC A
1977 |     C 2
     |=======|=======|=======|=======|=======|=======|=======|
 0.675   0.700   0.725   0.750   0.775   0.800   0.825   0.850
```

************************LEGEND*************************

TIME BOUNDS: 1962 TO 1977

SYMBOL	SCALE	NAME
A	#1	AGECAN
B	#1	AGEEST
C	#1	AGEWST

****

NOTA

SYMBOLS A, B AND C REFLECT CANADA, EAST AND WEST RESPECTIVELY.
TROLL COMMAND: .

decreased by only 20% to $150 million in 1970 and increased by 85% to $281 million in 1976. These different amplitudes in Eastern and Western investment cycles can also be seen through the relative age of the stocks. From Chart 4.8, it appears clearly that Western investment cyclical behaviour is much more pronounced than the Eastern one. Of course, the age of the stocks cycles are opposite to investment cycles.

The "one-hoss-shay" depreciation pattern over fifteen years assumed in this study, combined with the fifteen year investment cycle up to 1972, yield a stock of farm machinery relatively constant until 1972 as shown in Chart 4.9. Therefore, for the ten year period 1961-71, annual investment just offset the depreciation and no net investment occurred. Following 1972, the annual investment rate exceeded the assumed loss of depreciation equipment and the stock of farm machinery has continued to increase. The rate at which the stock has been increasing since 1972 is likely to slow down during the next few years since by definition, any increase in the stock level implies a level of sales greater than that which occurred fifteen years before, and sales for the period 1963-66 formed the peak of the investment cycle. However, if the stock level remains constant over the 1980's, it will represent an increase of about 35% over the 1960's in both Eastern and Western Canada.

CHART 4.9:

FARM MACHINERY STOCK BY REGIONS.
('00,000,000 OF 1971 DOLLARS)

```
   10.0      20.0      30.0      40.0      50.0      60.0      70.0
     |=========|=========|=========|=========|=========|=========|
1962 |         B            C                   A
     |         B            C                   A
     |         B            C                  A
     |         B           C                  A
     |        B            C                  A
1967 |        B            C                  A
     |         B           C                   A
     |         B           C                  A
     |         B           C                   A
     |          B          C                   A
1972 |          B          C                   A
     |           B          C                    A
     |            B            C                     A
     |             B            C                       A
     |               B            C                       A
1977 |                B              C                         A
     |=========|=========|=========|=========|=========|=========|
   10.0      20.0      30.0      40.0      50.0      60.0      70.0
```

***************************LEGEND*****************************

TIME BOUNDS: 1962 TO 1977

SYMBOL	SCALE	NAME
A	#1	STOCKCAN
B	#1	STOCKEST
C	#1	STOCKWST

****

NOTA

SYMBOLS A, B AND C REFLECT CANADA, EAST AND WEST RESPECTIVELY.
TROLL COMMAND: .

CHART 4.10:

REVENUE PER FARM AVAILABLE FOR INVESTMENT BY REGIONS.
(`00,000 OF 1971 DOLLARS)

```
   0.020       0.040       0.060       0.080       0.100       0.120
     |===========|===========|===========|===========|===========|
1962 |     B     A      C
     |      B    A    C
     |     B       A         C
     |       B        A        C
     |           B       A       C
1967 |          B        A       C
     |            B     A    C
     |              2B
     |            CA B
     |            B A  C
1972 |                   B    A    C
     |                           B     A     C
     |                              B           A          C
     |                              B            A          C
     |                           B     A    C
1977 |                        B   A  C
     |===========|===========|===========|===========|===========|
   0.020       0.040       0.060       0.080       0.100       0.120
```

**************************LEGEND****************************

TIME BOUNDS: 1962 TO 1977

SYMBOL	SCALE	NAME
A	#1	REVCAN
B	#1	REVEST
C	#1	REVWST

****

NOTA

SYMBOLS A, B AND C REFLECT CANADA, EAST AND WEST RESPECTIVELY.
TROLL COMMAND: .

Between 1961 and 1971, the number of farms decreased by 31% and 16% in Eastern and Western Canada respectively (see Chart 8 in Appendix C) without variation in the aggregate stock of machinery. A lesser decrease occurred between 1971 and 1977, i.e. 12% and 6% in East and West respectively but the capital stock level increased by about 35% in both regions. Production capacity in terms of farm machinery capital has increased significantly and the potential exists for greater exodus of farmers. However, this increase in production capacity also allowed farmers to reduce the risk attached to weather conditions by shortening the necessary time period for farming operations. Farmers could enjoy more leisure as well and moreover, a significant portion of capital expenditures went to utilitarian purchases (more comfortable cabs, radio, air conditioner...) and was not directly related to production capacity. It is possible that these "secondary" objectives were not reached in the sixties due to budgetary constraints. Chart 4.10 shows real revenue per farm in both regions as well as in Canada and it appears that the cycles occuring until 1971 are more or less equivalent to the farm machinery investment cycles. Starting in 1972 though, real farm revenue increased in both regions to reach a level 80% higher than the previous peak in the East and 67% higher than the previous peak in the West. It is then quite possible that the increase in farm machinery stocks serves the objectives mentioned above without forgetting that the potential capacity is still there and therefore, a decrease in the stock would not necessary imply a decrease in output production.

Structural equations of the demand for farm machinery.

The hypothesized farm machinery demand function is of the form:

$$KMACH = a0 + a1*MSR(-1) + a2*AGE + a3*REV(-1) + (1-k)*KMACH(-1) \tag{4.3}$$

where the estimated parameters are given in Table 4.8.

Upon initial inspection of Table 4.8, the goodness of fit of the equations ranges between 0.92 and 0.98 and all explanatory variables show the expected sign. The maintenance-stock ratio, as its expected sign could not be hypothesized , appears to be positive in Eastern Canada; negative in Western Canada; and mixed in Canada depending upon the equation specification. However, the only equation in which it appears to be statistically significant is equation FMEO. The AGE variable shows the expected sign and is statistically significant in all equations. Its level of significance however, appears to be lower in Eastern Canada.

TABLE 4.8

Estimated parameter values for the demand for Farm Machinery in Canada, Eastern and Western regions in linear and log-linear form.

Equation[1]	Constant	MSR(-1)	AGE	REV(-1)	KMACH(-1)	D-h[3]	R^2
Units	(1.0E+9)			(1.0E+6)	(1.0E+9)		
Canada							
FMCO	-1.27 (***)	-11.41	14.76 (***)	3.58 (**)	0.93 (***)	-0.37	.953
FMCL[2]	1.29 (**)	0.14	3.60 (***)	0.07	1.36 (***)	--	.982
East							
FMEO	-0.48 (**)	56.82 (*)	5.22 (**)	0.71	0.80 (***)	NA	.944
FMEL	2.93 (**)	0.38	2.06 (*)	0.20	0.78 (**)	NA	.915
West							
FMWO	-0.88 (***)	-38.19	10.32 (***)	2.55 (***)	0.93 (***)	0.50	.963
FMWL	0.91	-0.43	3.59 (***)	0.66 (**)	1.04 (***)	-0.84	.932

*, **, ***. Significance of the parameters at the 10, 5 and 1 percent level respectively;

1. The first two letters of the acronym stand for Farm Machinery, the third letter for the region; Canada, East or West, the fourth letter reflects whether the data are in Original (O) or logarithmic form (L).

2. Results shown have been corrected for autocorrelation using the technique provided by TROLL econometric package which is similar to a two-stage Cochrane-Orcutt method.

3. NA implies that the Durbin-h statistics could not be calculated.

TABLE 4.9

Short run and long run elasticity of the demand for Farm Machinery with respect to the explanatory variables and adjustment coefficients.

Elasticity[1]\equation	FMCO	FMCL	FMEO	FMEL	FMWO	FMWL
$e^{s}_{kmach.msr(-1)}$	-0.03	0.14	0.49	0.38	-0.17	-0.43
$e^{1}_{kmach.msr(-1)}$	-0.43	--	2.45	1.73	-2.43	--
$e^{s}_{kmach.age}$	2.42	3.60	2.13	2.06	2.73	3.59
$e^{1}_{kmach.age}$	34.57	--	10.65	9.36	39.00	--
$e^{s}_{kmach.rev(-1)}$	0.43	0.07	0.17	0.20	0.58	0.66
$e^{1}_{kmach.rev(-1)}$	6.14	--	0.85	0.91	8.29	--
$k : O^{2}$	0.07		0.20		0.07	
$k : L^{2}$		--		0.22		--

1. s stands for short run elasticity,

   1 stands for long run elasticity.

2. k is the coefficient and

   O reflects the equation using original data whereas

   L reflects the equation expressed in logarithmic form.

The other explanatory variable, i.e. REV(-1), although showing the positive expected sign in all equations, is statistically significant only in Western Canada and in equation FMCO. Values of the parameter of REV(-1) are also much larger in Western Canada. Table 4.9 points out the coefficients of elasticity of the different explanatory variables.

Within a region, both coefficients of elasticity, i.e. the ones from the log-linear equations and those calculated at the mean using linear equations, are relatively similar. This fact strengthens confidence about the magnitude of the proposed coefficients. One exception is the elasticity of KMACH with respect to MSR(-1) in Western Canada where the coefficient calculated at the mean appears to be smaller than the one given by the logarithmic equation, although neither one is statistically different from zero. With respect to the relative magnitude of the elasticity coefficients among regions, both specifications show the same type of relationship, that is, if a coefficient is smaller (larger) in the East using a given specification, the other specification also shows the same relation.

The negative sign of MSR(-1) in Western Canada associated with a large elasticity coefficient of the AGE variable might be interpreted as a tendency not to invest in repairing the stock of machinery but rather to invest in new machines. However, if repairs take place, the machine will be kept longer, thus postponing the investment that may have occurred the following year.

The AGE variable, namely the proportion of the stock of machinery older than three years shows a high level of significance with the expected sign. The investment elasticity with respect to this particular variable is significantly greater than one in all regions. An explanation of this phenomenon is that there are actually two farm machinery markets, one for new and one for used equipment. Even though the present study concentrates on the new market exclusively, the influence of both markets is present through this particular variable. Indeed, if the age of the stock increases, the group of farmers normally buying new machinery is likely supplemented with farmers accustomed to buying in the used market, because the stock and quality of used machines is declining. Therefore, the higher price and limited selection of used machines suggest more farmers will participate in the new machinery market. These two effects are both expected to affect new farm machinery sales and are reflected in the equation through the AGE variable which has a higher coefficient of elasticity than might have been expected a priori. The AGE-investment elasticity is higher in Western Canada than in Eastern Canada. This observation enhances the previous discussion about the assumption that Western farmers keep up with new technology more than Eastern farmers do. Eastern farmers can then be assumed to be more inclined to repair their machines but it will be easier to verify this hypothesis when discussing the next equation which deals with repair parts.

The revenue variable shows the highest coefficient of elasticity in Western Canada. Indeed, the amount of land per farm and the average size of machines are clearly larger in Western Canada. Western Canadians are more responsive to a variation in their budget since they invest in bigger and more contemporary machines when they can afford it and, on the other hand, postpone investment and use their existing stock when farm receipts drop. This is translated into a larger coefficient of revenue elasticity in the empirical results. The lowest coefficient of elasticity occurs in the log-linear equation for Canada. Theoretically this is not consistant since Canada's value should be between the Eastern and Western ones. Results from the linear equations are more acceptable since Canada's coefficient does lie between the Eastern's and Western's value.

The coefficients of adjustment which indicate the time farmers take to adjust their actual investment to an optimum level are quite different in the two Canadian regions. Eastern Canada shows a value of 0.2 in both specifications which means that within about five years, ceteris paribus, the optimum or desired level of investment would be reached. However, the Western Canada estimated coefficient is very small in equation FMWO (and smaller than zero in equation FMWL). The consequence is a rather long time of adjustment which is the opposite of what had been assumed previously, when it was hypothesized that Western farmers were more efficient. A possible explanation for this low coefficient of adjustment is that there was a very high trend in the demand for farm machinery which has not been picked up adequately by the other explanatory variables. Therefore, lagged investment seems to have an important influence, statistically speaking, on current demand. However, in the subsection "Demand for petroleum products", it has been mentioned that farmers in both regions seemed to be overcapitalized. The rational outcome of such a situation would be to "decapitalize" which would be reflected empirically by a negative adjustment coefficient. But, it has been shown that Eastern farmers seem to overcapitalize more than Western farmers and the inconsistancy of the above results is that the negative adjustment coefficient shows up in Western Canada.... Another tentative explanation is that assuming Western farmers continually keep up with technology, they are relatively close to the optimum level of investment which will never be reached and hence, the period of adjustment seems very long.

The long run coefficients of elasticity are not available for Canada or for Western Canada using the log-linear specification since the coefficients of the lagged endogenous variables appeared to be greater than one which theoretically implies these adjustment coefficients are negative. However, the linear specifications do show positive values for the adjustment coefficients in the West and Canada but their values are so small that the long run coefficients of elasticity derived from them do not seem to be realistic and so, are not discussed here. In Eastern Canada, the long run coefficients of elasticity of the AGE variable are high, as expected. However, the fact that the revenue elasticity is close to 1 implies that if the relationship between KMACH and REV(-1) encountered throughout the period under investigation continues, a given variation in the revenue variable will be reflected by the same variation in farm machinery investment and investable funds will have to be nil before investment in farm machinery stops. The result is that even though the numbers of farms decreased, (see Chart 8 in Appendix C) the aggregate demand for farm machinery is not affected inasmuch as the revenue per farm remains unchanged. This implication may not appear to be very realistic as such since at the limit, only one farm could buy all farm machinery with a relatively trifling revenue. However, as this conclusion has been obtained from an investigation over sixteen years, "long run" conclusions from the model should not be drawn for more than 8 or 10 years and by then, there will still be many thousands farms. However, the fact that aggregate investable revenue may decrease without affecting investment in new farm machinery can be interpreted the following way. In the long run, the demand for agricultural output is increasing due to the increase of the population and income but improvements in technology, if they continue at the same rate as in the sixties and seventies, permit output to increase more rapidly than aggregate demand. This may lower prices and less competitive farmers will leave agriculture since, in real terms, they suffered a decrease in their revenue. However, the farmers who did stay in production are still there because they invested in new technology. Therefore, even with a constant revenue per farm, investment in new machinery may not be affected by a decrease in aggregate farm revenue since the number of farms would decrease adequately in a competitive market. It is clear from the above discussion that improvement in technology keeps prices from increasing with aggregate demand and it is also clear that in the long run, the substitution of labor for capital does, and should occur.

Historical validation and simulation.

Table 13 to 18 and Charts 7 to 9 in Appendix B are related to the demand for farm machinery in Eastern and Western regions as well as in Canada. As discussed previously, farm machinery investment is cyclical in both Eastern and Western Canada with an amplitude considerably greater in Western Canada. Tables 17 and 18 and Chart 9 in Appendix B show that demand estimated by O.L.S. is more accurate than demand simulated. The first turning point occurred in 1966. Estimated sales were predicted to go down although they had underestimated actual demand by 10%. The second turning point occurred in 1970 where the sales in farm machinery started to increase until 1976. Estimated sales though, were pridicted to start increasing one year later in 1971, but they did follow closely the ascending portion of the cycle until 1976. The third turning point occurred in 1976 and estimated sales also went down but they were 3% short of actual demand in the cycle. The simulation procedure failed to predict the first turning point and predicted decreasing sales too early. The first simulated peak therefore occurred at a level 16% lower than the actual one in 1966. The second turning point underestimated the actual one by 21% and was predicted to occur in 1971. However, the third one in 1976 occurred at a value where simulated sales of farm machinery were equal to actual sales.

Estimated and simulated demand did not perform as well in the East as they did in the West although this relatively inferior outcome is in accordance with statistical estimates. For the periods 1962-66 and 1972-77, both estimated and simulated investment levels followed the general tendencies of the actual level of investment. However, for the period 1967-71 where short "cycles" occurred, simulated sales of farm machinery were predicted to go up steadily. Estimated sales though seem to be one year behind these "cycles". For instance, actual sales decreased from 1967 to 1968, increased from 1968 to 1969 and decreased again in 1970 whereas estimated sales show the exact opposite behaviour. More sophisticated analysis would be required to explain these unpredicted fluctuations.

Generally, the simulation procedure does not perform as well as estimation by O.L.S. as Table 4.10 shows. The RMS percent error is about 30% higher than the SEE% in Eastern Canada and 85% higher in Western Canada. This is because several exogenous variables are indirectly a function of farm machinery sales and any mistake in simulated output for a given year is carried along by three explanatory variables, i.e. AGE, MSR(-1) and KMACH(-1). On the other hand, actual variables are used in estimation procedure and the residual of a specific year does not influence the estimated level of demand the following year.

TABLE 4.10

Standard error of estimates (SEE) and percentage of SEE at the mean, root mean squares (RMS) and RMS percent error related to the demand for Farm Machinery in Canada, Eastern and Western regions.

Equation[1]	SEE	$SEE\%_{mean}$	RMS	RMS%
Canada				
FMCO	0.37	7.96	0.47	12.18
East				
FMEO	0.16	8.34	0.17	10.70
West				
FMWO	0.23	7.99	0.33	14.71

1. The equations retained were those which showed the best performances in term of R^2, t-values of the parameters and SEE.

Related material.

According to standard economic theory, firms produce according to a given production function and any derived input demand functions are derived under strict theoretical assumptions. Rational producers are assumed to maximize profits given a certain cost function and the input demand can generally be expressed as a function of price ratios (i.e. price of the input demanded versus the price of output and the price of the input demanded versus the price of any other inputs included in the production function). This type of derived input demand implies absence of money illusion i.e. the input demand functions are homogenous of degree zero in prices (see Henderson & Quandt, pp 24 and 69). There is also no adjustment period and investors are assumed to react to prices instantaneously. Another limiting assumption is that capital is always intrinsically supposed to be used at its optimum level every year. Therefore, input demand derived from a marginal analysis does not take into account the actual degree of utilization of the stock of machinery and obviously, the price of machinery could go down or the price of labor go up without necessary increasing the farm machinery demand level. Also, funds are assumed to be available without restraint through a perfect capital market. Limited borrowing capability and variation in the interest rates do have an important role in the investment decision. Consequently, most empirical studies employ more variables than price ratios to explain investment behaviour.

Several studies incorporate at least two price ratios, namely the price of machinery to the price of output and the price of machinery to the price of labor. As well they contain an income variable as a proxy for the budget constraint and other price ratios because variations in the ratios of the price of farm machinery to other inputs would possibly change the proportion of farm machinery expenses to other input expenses. This change in proportion would be reflected in the income variable, at least as far as intermediate inputs are concerned. A specification error occurs inasmuch as the price of output and the price of labor are concerned. A variation in the price of output will directly affect the income variable except in the special case when the price elasticity is exactly equal to one. For the price of labor, as it is a current year expense, the effect of any variation in its level has already been taken into account in the costs and revenue available for investment. Hence, current investment has already been corrected for the shift in relative prices.

Theoretically, the ratio of the price of machinery to the price of labor is expected to show a negative sign due to the substitution effect. The decision to invest in farm machinery involves a rather long span of time, assumed to be fifteen years in this study, and since disinvestment is unlikely due to price difference in the used and new markets, farmers' expectations about prices (machinery and labor) are likely to be more important than present prices in determining the level of investment. Therefore, inasmuch as time series analyses are concerned, a long period of time (40 to 50 years) should be investigated in order to actually determine the substitution that occurred between capital and labor. One of the major shortcomings in such long run analysis is a lack of consistency in the data. This limitation can partly explain why most studies show an insignificant and positive sign for the O.L.S. parameter for the ratio of the price of farm machinery to the price of labor. However, two main phenomenon could be pointed out as a tentative explanation for this.

Firstly, the theoretical expected substitution between farm machinery and labor did and does actually occur and would tend to give a negative sign to the ratio of the price of machinery to the price of labor.. It is widely accepted that the introduction of more machinery does contribute to increase farmers' capability to cultivate more land and hence produce more output on a per man basis. Had it been more economical to continue to produce with people and animals rather than machines, the substitution that occurred would not have taken place. However, the difference between marginal costs of using machinery and marginal revenues that it procured was so important that farmers made use of the new technology quite rapidly. Adoption of the new technology brought about cost reductions allowing more than normal profit and creating pressure for adoption by all farmers. As the technology was adopted by more farmers; production increased, revenues fell and those who failed to adjust left the agricultural industry.

Currently, there is less likely potential for a major substitution between capital and labor in industrial countries. Even a drastic increase in the price ratio would not force farmers to previous farming methods since it is nearly impossible to hire enough labor to replace machines. With such a high level of mechanization, a higher increase in the price of labor than in the price of machinery can be expected since the increase in the price of machinery also reflects technological improvements. In order to operate more sophisticated machines, hired labor has to possess more skill and of course, this is reflected in its price. Therefore even if the price of labor increases more rapidly than the price of machinery, substitution may not occur and the positive sign of the ratio of the price of machinery to the price of labor could be interpreted at the margin to mean that the farmer is financially unable to pay more labor which is, to a certain extent, a complement to machinery.

Another factor which contributes to the insignificance and wrong theoretical expected sign (positive) of the price of machinery to the price of labor ratio is the unavailability of specific relevant information on labor. With a decline in average work week and better job stability in other sectors of the economy; it is normal that farmers seek to more leisure time and a reduction in risk. One way to accomplish this is to buy more efficient and larger machines which shorten the time necessary to accomplish farming operations. A substitution from labor to capital has taken place but accurate data related to hours actually worked are impossible to obtain. The actual substitution from labor to capital is consequently underestimated.

Another factor which might dampen the price effect in the input demand equation is the accessibility to credit. In order to reduce risk and enjoy more leisure, farmers are able to pay higher prices for farm machinery because with increased competition among credit institutions, it has become easier to obtain credit in Canada.

However, for comparison purposes, the ratio of the price of machinery to the price of output and the ratio of the price of machinery to the price of labor have been tried in the hypothesized farm machinery demand function and as found by several other researchers, their coefficients were insignificant and had the wrong theoretical expected sign.

Another price variable has also been embodied in the farm machinery demand function i.e. the real price of machinery which was defined as the price index of farm machinery deflated by the GNE-implicit price index. This definition also appeared to be statistically insignificant with the wrong expected sign and even caused the revenue variable in the East, which has a correlation coefficient of 0.95 with the endogenous variable, to have a negative sign. This was due to the very high degree of correlation between real price and REV(-1) which is -0.67 and -0.95 in Eastern and Western Canada respectively.

The revenue variable was defined in several ways in addition to the real revenue on a per farm basis. The other specifications were: aggregate revenue, revenue per acre and individual farm revenue. The revenue itself was also specified as a mathematical three-year weighted average but, even though this definition performed very well, it had to be rejected because of the loss of two additional degrees of freedom.

The maintenance-stock ratio variable, although not significantly different from zero in Canada and Western Canada, was kept in these equations for comparison purposes and also, MSR is necessary for the system to be recursive. Further, the hypothesized relationship is based on the MSR being included. Removing this variable would violate the hypothesized structure of the equations. In terms of forecasting, the presence of the variable will not significantly alter the conclusions drawn.

As to the relatively poor results in Eastern Canada with respect to the significance of the parameters, attempts were made without success to avoid multicollinearity among variables which might have been the source of the problem. There must be then, other unidentified specific reasons which caused farmers in Eastern Canada to invest in farm machinery.

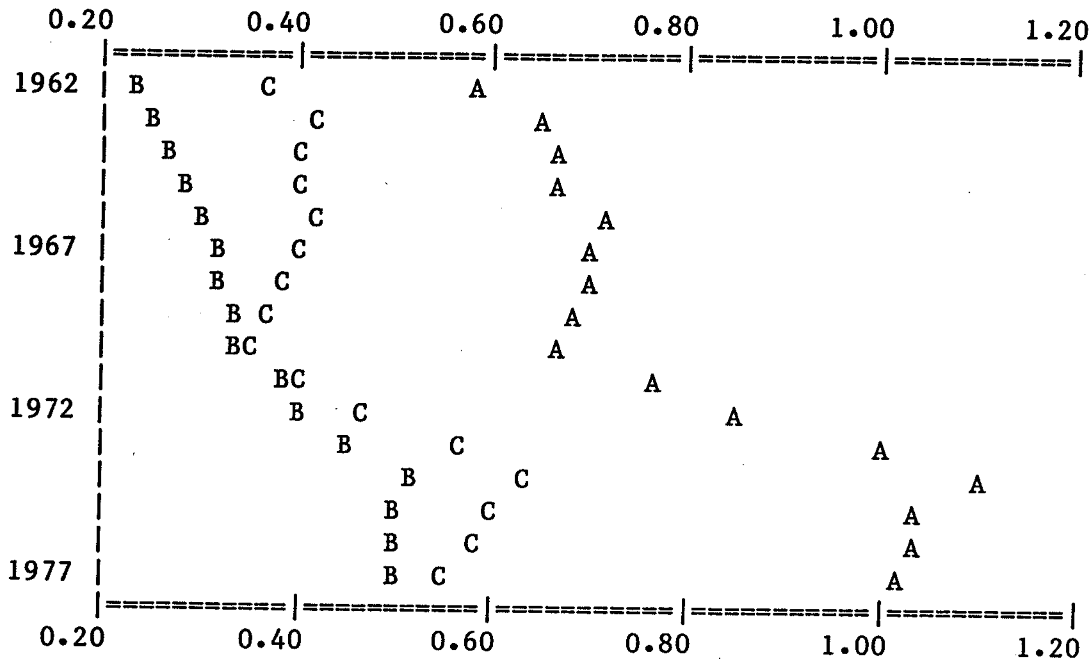
Repair parts

Demand for repair parts.

Chart 4.11 indicates the demand for repair parts differs considerably between Eastern and Western Canada. Eastern demand has been increasing throughout the period under investigation, except for the last four years when it was rather constant. In Western Canada though, the demand remained unchanged between 1962 and 1971, increased steadily until 1974 to reach a level 65% higher than its previous constant level and then dropped by 14% in the last three years. The maintenance-stock ratios (MSR) shown in Chart 4.12 have the same trend as the demand for repair parts

CHART 4.11:

DEMAND FOR REPAIR PARTS BY REGIONS.
('00,000,000 OF 1971 DOLLARS)



**************************LEGEND****************************

TIME BOUNDS: 1962 TO 1977

SYMBOL	SCALE	NAME
A	#1	KREPCAN
B	#1	KREPEST
C	#1	KREPWST

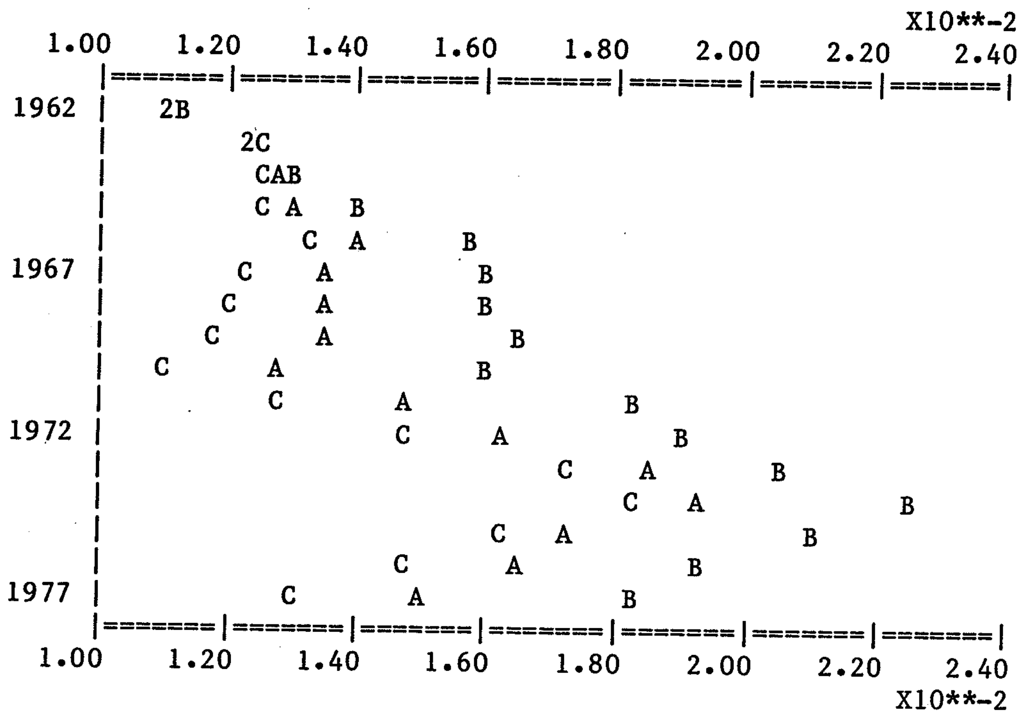
****

NOTA

SYMBOLS A, B AND C REFLECT CANADA, EAST AND WEST RESPECTIVELY.
TROLL COMMAND: .

CHART 4.12:

MAINTENANCE-STOCK RATIO BY REGIONS.



************************LEGEND*************************

TIME BOUNDS: 1962 TO 1977

SYMBOL	SCALE	NAME
A	#1	MSRCAN
B	#1	MSREST
C	#1	MSRWST

****

NOTA

SYMBOLS A, B AND C REFLECT CANADA, EAST AND WEST RESPECTIVELY.
TROLL COMMAND: .

because the stock of farm machinery stayed relatively unchanged between 1961 and 1972 (see Chart 4.9). Therefore, any variation in the demand for repair parts caused a similar change in the MSR. It is useful to recall that the stable nature of the stock of farm machinery occurred despite wide and cyclical fluctuations in annual investment shown in Chart 4.7. For the remaining years of the period investigated, both the demand for repair parts (KREP) and the maintenance-stock ratio (MSR) can be divided into two sub-periods in both regions. For the years 1972 to 1974, KREP and MSR were increasing at a greater rate than the stock of machinery (STOCK). Therefore, the relative increase in KREP was necessarily higher than the relative increase in STOCK. This is easy to accept since the stock of farm machinery is by definition the sum of annual investments over the past fifteen years and a 10% increase in the demand for repair parts in the current year must be preceded by a level of investment 150% higher than it was sixteen years ago in order to keep MSR unchanged; and such an increase in the level of investment is rarely reached. Due to high levels of farm machinery investment after 1973, the stock of farm machinery became newer and the level of repair parts decreased. Therefore, with a growing stock, it is obvious that MSR had to decrease at a higher rate than the demand for repair parts which is shown in Chart 4.11 and 4.12.

Structural equations of the demand for repair parts.

As mentioned in the previous chapter, demand for repair parts is estimated in an indirect way under the form of the maintenance-stock ratio. As the value of stock is taken at the beginning of the year by definition, it is already known for the coming year and repairs can be estimated directly using a simple multiplication.

The hypothesized relationship is expressed as:

$$MSR = a0 + a1*AGE + a2*USE + a3*CASH \tag{4.4}$$

Results in Table 4.11 show all equations performed well in terms of goodness of fit, significance of the parameters and expected theoretical signs. The only variable which is not statistically significant at the 5% level or less is AGE in Eastern Canada and in equation MSRCL.

Table 4.12 gives the elasticities of MSR with respect to explanatory variables. As it is shown, within a specific region, the coefficients of elasticity from the log-linear equations are similar, if not almost identical, to those calculated at the mean using the linear equations. The same relative magnitude also exists between regions with both specifications. That is, if a given parameter is greater

TABLE 4.11

Estimated parameter values for the Maintenance-Stock Ratio functions in Canada, Eastern and Western regions in linear and log-linear form.

Equation[1]	Constant	AGE	USE	CASH	R^2
Units	(1.0E-3)			(1.0E+3)	
Canada					
MSRCO[2]	-6.3	0.0061	0.17	14.6	.969
	(**)	(**)	(***)	(***)	
MSRCL[2]	-3.96	0.24	0.39	0.58	.941
	(***)		(***)	(***)	
East					
MSREO[2]	-1.2	0.0010	0.13	22.5	.974
			(***)	(***)	
MSREL[2]	-2.74	0.04	0.21	0.71	.967
	(***)		(***)	(***)	
West					
MRSWO[2]	-8.5	0.0112	0.14	9.1	.996
	(***)	(***)	(***)	(***)	
MSRWL[2]	-4.48	0.59	0.44	0.53	.989
	(***)	(***)	(***)	(***)	

---

*, **, ***. Significance of the parameters at the 10. 5 and 1 percent level respectively;

1. The first letters of the acronym stand for Maintenance-Stock ratio, the fourth letter for the region; Canada, East or West, the fifth letter reflects whether the data were in Original (O) or logarithmic (L) form.

2. Results shown have been corrected for autocorrelation using the technique provided by TROLL econometric package which is similar to a twostage Cochrane-Orcutt method.

TABLE 4.12

Short run elasticity of the Maintenance-Stock Ratios with respect to the explanatory variables.

Elasticity[1]\equation	MSRCO	MSRCL	MSREO	MSREL	MSRWO	MSRWL
$e^{s}_{msr.age}$	0.32	0.24	0.04	0.04	0.64	0.59
$e^{s}_{msr.use}$	0.52	0.39	0.30	0.21	0.46	0.44
$e^{s}_{msr.cash}$	0.67	0.58	0.73	0.71	0.53	0.53

1. s stands for short run elasticity.

Given the specification of this equation, the long run elasticities are not available.

(smaller) in Eastern than in Western Canada using the log-linear equations, it is also greater (smaller) using the linear equations.

In Western Canada, the elasticity of MSR with respect to AGE is much higher than in Eastern Canada but appears to be significantly smaller than one with a value of about 0.6. This coefficient of elasticity is rather small taking into account the way the present equation is specified. First, one should recall that the AGE variable, with an expected value of 0.80 by definition, cannot increase by more than 25% which implies no investment in farm machinery occurred for three years in a row. Actually, the highest and the lowest values of AGE happened to be in Western Canada with values of 0.835 and 0.692 respectively (see Chart 4.8). It should be noted that the average value of AGE for the period investigated is 0.77 in both East and West due to an upward trend in farm machinery investment. As to the year to year variations, the highest ones were 4% and 6% in Eastern and Western Canada respectively. Hence, variations in AGE cannot and do not have large magnitudes. The AGE-investment elasticity is however expected to be relatively high or at least greater than one since according to the Agricultural Engineering Department, University of Illinois, most agricultural machines have an exponential repair cost function with respect to their purchasing price (FMO pp. 90-91). Therefore, as a machine gets older, necessary repair costs are rising at an increasing rate which implies that as a stock of machinery gets older, repair costs relative to the stock (MSR) are expected to rise at an increasing rate. The relatively low AGE-elasticity in Western Canada probably means farmers are not inclined to make expensive repairs on old machinery and would rather replace them after having made the minimum repairs to finish the working season(15). In passing, this is in accord with the rather high coefficient of elasticity of this variable with respect to investment in farm machinery. Moreover, this is confirmed by a relatively low coefficient of elasticity of the CASH variable which means that even though farmers have the money to undertake the necessary repairs, an increase in CASH would not greatly affect the incentive to repair. On the other hand, a decrease in CASH would not greatly affect MSR either, since the repairs that are effected have to be made in order to complete farming operations.

In Eastern Canada the higher elasticity of demand with respect to CASH implies farmers are more inclined to repair their machines. This fact could partly explain why AGE is not significant in Eastern Canada. Indeed, if relatively

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(15)This would not necessarily be the case if the ratio of "revenue available to make repairs" to the total stock of machinery in Western Canada was different from this ratio in the Eastern Canada. However, those two ratios are quite similar over time, either at the aggregate level or on a per farm basis.

more repairs are effected, the condition of the machines remains better and the relationship between repairs and the age of the machine is less obvious.

With respect to the factor of utilization (USE), it is quite significant in all regions. The higher coefficient of elasticity in Western Canada might be interpreted as a higher degree of machine utilization. Indeed, when a machine is utilized close to its maximum capacity, the probabilities of a breakdown increase. An indirect way to test this hypothesis is to look at the energy consumed relative to the stock. Chart 4.13 reports the ratios of petroleum products expenditures to the working stocks of machinery and Western ratio is actually higher than Eastern ratio, especially in the seventies.

Generally, a point which is common to all equations is that MSR is more sensitive to the degree of utilization of machinery than to the age of the stock considering that USE can vary much faster than AGE. Also, the higher the responsiveness of MSR to CASH, the lower its responsiveness to AGE. This could indicate that when farmers repair their machines on a continuous basis, the age of the stock does not appear to be as important a variable in explaining the MSR variations.

CHART 4.13:

PETROLEUM PRODUCTS EXPENDITURES VERSUS THE WORKING STOCK OF CAPITAL BY REGIONS.

```
                                                           X10**-2
    2.25      2.75      3.25      3.75      4.25      4.75      5.25
     |=========|=========|=========|=========|=========|=========|
1962 |                                  B  AC
     |                                     B2
     |                                     B 2
     |                                        B 2
     |                                        B  AC
1967 |                                          B   2
     |                                            B   AC
     |                                             B    AC
     |                                               B   AC
     |                                           B      A  C
1972 |                                          B      A   C
     |                                    B          A    C
     |                     B                    A          C
     |          B                  A          C
     |    B                    A          C
1977 B                      A            C
     |=========|=========|=========|=========|=========|=========|
    2.25      2.75      3.25      3.75      4.25      4.75      5.25
                                                           X10**-2
```

**************************LEGEND****************************

TIME BOUNDS: 1962 TO 1977

SYMBOL	SCALE	NAME
A	#1	OILSTKCA
B	#1	OILSTKES
C	#1	OILSTKWS

****

NOTA

SYMBOLS A, B AND C REFLECT CANADA, EAST AND WEST RESPECTIVELY.
TROLL COMMAND: .

Historical validation and simulation.

Actual, estimated and simulated demands for repair parts are reproduced in Appendix C by Tables 19 to 24 and Charts 10 to 12.

Estimated demand by O.L.S. performs slightly but not significantly better especially if one considers that all four simulated equations are indirectly included in this particular function. Indeed, AGE includes simulated results from the farm machinery demand equation which includes lagged simulated results of the repair parts demand equation. USE includes simulated results from the petroleum products demand equation which includes simulated results from the pesticides demand equation.

Table 4.13 gives the RMS and the RMS percent error of simulated demand for repair parts. With a RMS percent error around 5% in both regions as well as in Canada, it can be stated that the test of the whole system of equations using simulation procedure confirms the hypothesized relationships among the demand for pesticides, petroleum products, farm machinery, repair parts for farm machinery and the exogenous explanatory variables.

TABLE 4.13

Root mean squares (RMS) and RMS percent error related to the demand for Repair Parts in Canada, Eastern and Western regions.

Equation[1]	RMS	RMS%
Canada		
MSRCO	0.04	4.58
East		
MSREO	0.02	5.33
West		
MSRWO	0.02	4.75

1. The equations retained were those which showed the best performances in term of R^2, t-values of the parameters and SEE.

Related material.

In this equation again, AGE has been divided into 2 or 3 strata but using only one, i.e. part of the stock older than three years, appeared to be as satisfactory and reduced multicollinearity among variables.

One of the main shortcomings of this equation is that the deflator of repair parts is the price index of farm machinery which is of course not adequate but had to be used, since the price index for repair parts is not available prior to 1971. Elaboration about this shortcoming is provided in a later subsection; "Quantity demanded for repair parts."

Forecasts for the period 1978 to 1980

The present model can be described as a "short run" forecasting model since predictions of exogenous variables are not attempted rigorously. Besides, the effects of any major policy specially dedicated to influence the demand for a given input are not yet taken into consideration. Therefore, it seems inconsequential to keep track of previous errors in the simulation process for forecasting purposes and simulated results presented hereafter are derived from actual data whenever possible. To be more explicit, results for 1978 are derived using actual data up to 1977 and results for 1979 and 1980 are predicted on the basis of recorded observations up to 1978. Simulated results for 1978 will be compared to recorded observations as well as estimates determined by ordinary least squares. Given the forecasting procedure utilized, the only estimates differing between O.L.S. and simulation procedure are when the demand functions are related to endogenous variables determined within the recursive system. These include the demand functions for petroleum products and repair parts. Since the demand functions for pesticides and for farm machinery are dependant upon exogenous and lagged endogenous variables, both estimated (O.L.S.) and simulated estimates will be exactly the same. It is also evident that forecasted expenditures for 1979 and 1980 will be identical either from estimation or simulation procedures since actual exgenous variables are used up to 1978.

The next subsection shows the procedure utilized to approximate exogenous variables for the forecasted years. However, it should be mentioned that all exogenous variables are subject to more sophisticated analysis elsewhere. In order to have more "theoretically" reliable predicted values, proxies for exogenous variables used in the present analysis could be replaced by forecasted values from other econometric models. For instance, the GNE-implicit price index and the Gross Private Business Products deflator are forecasted by the Bank of Canada econometric model (RDX2). The price index of agricultural inputs as well as the revenue variables are also forecasted by different forecasting models used by Agriculture Canada. The present model could therefore be embodied in a more general macro model which would predict or put more emphasis on the present exogenous variables without any a priori restrictions.

Before going further it should be recalled which equations were employed in the recursive system. they are: PCL, PEL, PWO; PPCO, PPEL, PPWL; FMCO, FMEO, FMWO; MSRCO, MSREO and MSRWO for pesticides, petroleum products, farm machinery and repair parts respectively. The equations retained were the ones which showed the best performance in terms of R ; t-values of the parameters; and in most cases the lowest standard error of the regression.

<u>Procedure employed to approximate the exogenous variables for the forecasted years</u>

In order to forecast the demand level for the four agricultural inputs considered in this study, proxies for exogenous variables had to be assumed. This subsection deals with the procedure utilized to "forecast" the exogenous variables. Plots of these variables are reproduced in Appendix C showing the actual values for the period 1962 to 1977 or 1978 depending upon whether the value was available or not in 1978, and the value of the proxy variables from 1977 or 1978 to 1980.

Demand for pesticides.

$$KPEST = f(RPC, REVCR(-1), DUM, TIME, KPEST(-1)) \qquad (4.1)$$

RPC : By definition, the real price of chemicals is the agricultural insecticides and pesticides price index divided by the GNE-implicit price index. Actual values for both indexes are available up to 1978 and values for 1979 and 1980 are approximated assuming a growth rate equal to the actual average geometric rate of growth for the last four years i.e. 1975-78. (See Appendix C, Charts 1 and 2).

REVCR : The revenue variable is defined as cash receipts from crop sales in constant dollars, using the GNE-implicit price index as deflator, divided by the number of acres under crop. Values for farm cash receipts from crop sales are available up to 1978 and values for 1979 and 1980 are assumed to be the average value in constant dollars of 1975-78. The extrapolation of the GNE-implicit price index is described in the variable RPC. Actual values for the number of acres under crop are available up to 1977 and values for 1978-80 are assumed to be the average of 1974-77.

(See Appendix C, Charts 2, 3 and 5).

DUM : Dummy variable which takes the value 0 in 1978-80.

TIME : Dummy variable which takes the values 1978, 1979 and 1980 for the mentioned years.

Demand for petroleum products.

KOIL = f(RPO, STK, AFS, KPESTA) (4.2)

RPO : The real price of petroleum products is defined as the price index of petroleum products deflated by the GNE-implicit price index. The price index of petroleum products, available until 1978, is hypothesized to grow at a rate equal to the average geometric rate that occurred during the last four years i.e for the period 1975-78. The procedure used to extrapolate the GNE-implicit price index is defined above for the variable RPC.

(See Appendix C, Charts 2 and 6).

AFS : Average farm size is defined as total improved acres divided by the number of farms. As both variables are available on Census years only, values for the period 1978-80 are merely linear extrapolations of actual values in 1971 and 1976.

(See Appendix C, Charts 7 and 8).

KPESTA : This variable is defined as the average expenditures on pesticides in constant dollars (KPEST) divided by the number of acres under crop. KPEST is endogenous to the system and the methodology to get proxies for total area under crop is defined above in the variable REVCR.

(See Appendix C, Chart 5).

STK : Endogenous variable to the system.

<u>Demand for farm machinery</u>.

KMACH = f(MSR(-1), AGE, REV(-1), KMACH(-1)) (4.3)

REV : The revenue variable is defined as farm cash receipts minus farm operating expenditures in constant dollars, using the price deflator gross private business products, divided by the number of farms. The procedure used to extrapolate the number of farms is described in the variable AFS. The price deflator, available until 1978, is extended until 1980 using the average geometric rate of growth for the period 1975-78. The average value in constant dollars of the period 1975-78 is utilized for the period 1979-80 for the variable "farm cash receipts minus operating expenditures".

(See Appendix C, Charts 4, 8 and 10).

MSR(-1), AGE and KMACH(-1) are three endogenous variables to the system. However, the farm machinery price index which is the deflator of these three endogenous variables has also been extrapolated using its average geometric rate of growth for the period 1975-78. (See Appendix C, Chart 9).

<u>Demand for repair parts</u>.

$$MSR = f(AGE, USE, CASH) \tag{4.4}$$

Only the variable CASH in equation (4.4) is exogenous to the system. It is defined as farm cash receipts minus farm operating expenditures in constant dollars on a per farm basis where expenditures on repairs have not yet been taken into account. The procedures used to estimate the deflator and the number of farms are defined for the variable REVCR whereas the constant revenue variable is assumed to take the average value for the period 1979-80. (See Appendix C, Charts 4, 8 and 11).

<u>Quantity demanded for pesticides</u>

Table 4.14 shows actual sales of pesticides in Canada, Eastern and Western regions for 1978 versus estimated sales by O.L.S. and simulated sales as well as forecasts for 1979

TABLE 4.14

Actual versus estimated (O.L.S.) and simulated expenditures on Pesticides in nominal and constant (1971) dollars and predictions in Canada, East and West.

	CANADA (1.0E+6)	EAST (1.0E+6)	WEST (1.0E+6)
Actual expenditures.			
1978: nominal $	220.8	80.2	140.6
constant $	84.6	30.7	53.9
Estimated Expenditures.			
1978: nominal $	221.6	71.5	141.9
constant $	84.9	27.4	54.4
% error[1]	0.4%	-10.8%	0.9%
Simulated expenditures.			
1978: nominal $	221.6	71.5	141.9
constant $	84.9	27.4	54.4
% error[1]	0.4%	-10.8%	0.9%
Predictions.			
1979: nominal $	252.5	80.6	155.1
constant $	93.6	29.9	57.5
1980: nominal $	302.5	87.1	172.7
constant $	108.4	31.2	61.9
Standard error of the regressions[2]. (1971 dollars)			
1978:	5.0	2.9	2.0
1979:	5.5	3.1	2.0
1980:	6.4	3.3	2.0

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1. As the deflator is exogenous to the system, the percentage of error is the same either in nominal or constant dollars.

2. As Eastern's and Canada's equations are expressed in log-linear form , the standard error of the forecasted values, back in their original form, has to vary with the magnitude of the values.

and 1980. As mentioned above, since the demand for pesticides is a function of exogenous variables only, both estimated and simulated results give the same values. Forecasted values for 1978 are quite close to the actual values in Canada and Western Canada with a percentage of error lower than 1%. However, the forecast in Eastern Canada underpredicts the actual level of demand by 11%. This is not surprising since it has already been mentioned that Eastern demand equation does not perform as well as Western and Canadian equations, which implies that higher percentage of error can be expected.

Forecasts for 1979 show the demand level is expected to increase in Canada and Western Canada whereas a slight decrease should occur in the East. In 1980 though, Eastern and Western demand levels are both expected to increase relative to 1979 by 4.6% and 7.6% respectively. It might be pointed out here that forecasted values for 1979 and 1980 emphasize the trend that has showed up since 1974 where the Western demand level exceeds the Eastern and is continually increasing. Its growth rate is expected to be 6.7% in 1979 and 7.6% in 1980.

If the forecasted level of Canadian demand is compared to the sum of the forecasted levels of Eastern and Western demand, it appears that the two estimates of 1979 and 1980 values are about 7.1% and 16.4% higher respectively. These differences can be attributed partly to the different specification employed in the East since the two dummy variables are not present in that equation. They can also be due to the fact that the equations reflecting the demand in the East and Canada are specified in logarithms whereas the equation reflecting Western demand uses untransformed data. Another possible source causing these differences is aggregation bias. One of the main reasons the demand functions were specified separately for Eastern and Western Canada was to examine whether different relationships exist in both regions between certain hypothesized explanatory variables and the demand behaviour for a given input. Therefore, it is expected, when data are aggregated, the regression parameters would be biased toward the region which has the most weight on the aggregated variables. Thus, the forecasted results from Canada's equation are likely to be different than the sum of forecasted results from regional equations. In the case of the demand for pesticides, one may suspect Canada's equation will underestimate Canadian demand. Indeed, looking back at Table 4.1 it can be noted that the coefficient of the price variable which is negative and affects the demand downward, is about the same in Canada and Eastern Canada whereas Western demand equation has a coefficient significantly lower in absolute terms. Of course, the TIME variable tends to affect the demand from Canada's equation upward but one should keep in mind that this variable increases at a slower rate than the price variable.

Quantity demanded for petroleum products

As this equation embodies endogenous variables in the system, estimated and simulated demand levels for 1978 are slightly different. Simulated demand uses results from the pesticides equation (KPESTA) and from the farm machinery equation (STK) whereas estimated demand uses actual values for these variables. However, Table 4.15 shows that results of both estimated and simulated demands are about the same and underpredict the actual level of the demand in 1978. Here again, Canada's forecasted result is not quite comparable to the regional summation. It could be argued that since the difference is only about 4% (4.3% using estimated demand and 3.5% using simulated demand) both ways of calculating the aggregate demand level can be assumed to be equivalent. It should be mentioned however that the standard errors of the regressions are very low (lower than 1%) and the difference between Canadian demand from Canada's equation and the summation of regional demands is more significant than for the case of pesticides for instance.

Forecasts for 1979 show that the Canadian demand level will remain about the same as 1978 actual level in nominal dollars which implies a falling demand level in constant

TABLE 4.15

Actual versus estimated (O.L.S.) and simulated expenditures on Petroleum Products in nominal and constant (1971) dollars and predictions in Canada, East and West.

	CANADA (1.0E+6)	EAST (1.0E+6)	WEST (1.0E+6)
Actual Expenditures.			
1978: nominal $	519.6	143.8	375.7
constant $	265.0	70.0	197.4
Estimated expenditures.			
1978: nominal $	478.5	132.7	361.4
constant $	244.0	64.6	190.0
% error[1]	-7.3%	-7.7%	-4.0%
Simulated expenditures.			
1978: nominal $	481.6	132.8	360.7
constant $	245.6	64.6	189.6
% error[1]	-7.3%	-7.7%	-4.0%
Predictions.			
1979: nominal $	520.3	138.3	399.3
constant $	242.0	61.3	191.4
1980: nominal $	571.6	144.4	441.0
constant $	242.5	58.4	192.9
Standard error of the regressions[2]. (1971 dollars)			
1978:	2.4	0.51	1.57
1979:	2.4	0.49	1.58
1980:	2.4	0.46	1.60

1. As the deflator is exogenous to the system, the percentage of error is the same either in nominal or constant dollars.

2. As Eastern's and Western's equations are expressed in log-linear form, the standard error of the regional equations has to vary with the magnitude of the values.

dollars. Even though the summation of forecasted expenditures on petroleum products from Eastern and Western equations are a little higher (3.3%) than the value obtained from Canada's equation, the expected decrease in Canadian expenditures in 1979 can be explained in the following way. Eastern expenditures are expected to fall in nominal dollars which implies a greater drop in real expenditures whereas Western expenditures are expected to increase in nominal terms and its real expenditures are expected to decrease.

Canadian prediction for 1980 appears to be about the same in constant dollars as 1979 prediction. Generally speaking, since the summation of forecasted regional expenditures is still higher than forecasted expenditures from Canada's equation, this relatively stable Canadian demand level seems to be the result of a small decline in Eastern Canada which is almost offset by an increase in Western Canada. Of course, the relative decline in the East is markedly greater than the relative increase in the West since the magnitude of the demand in the West is about three times that in the East. However, due to the negative sign of the stock of machinery variable in Eastern and Canada, estimation of the parameters of this input demand equation should be updated yearly in order for it to remain reliable. As mentioned previously, two different information sources are inconsistant with respect to the behaviour of Eastern demand and such discrepancies should be clarified before drawing any important conclusions from the present estimated equation, but time limitations dictated against further analysis.

Quantity demanded for farm machinery

As Table 4.16 shows, both estimation and simulation procedures provide the same predictions for 1978 since endogenous variables to the recursive system for this particular equation are either lagged (MSR(-1) & KMACH(-1)) or set at the end of the year (t-1) by definition (AGE). Forecasted investment demand for 1978 failed to predict the actual demand for Canada, underestimating it by 12%. This is mainly because Western sales were underpredicted by 21%; the largest error since 1970 where the percentage of error was close to 40%. This large margin of error in the West could be due to a rather low revenue per farm in 1977, and as the coefficient of this variable is particularly high, (2.5 compared to 0.7 in the East) lagged revenue did have a serious dampening effect on Western investment. However in 1978, real revenue per farm increased by 14% after having declined for two years, and farmers might have decided to invest on their expected revenue for the current year. One way to verify this hypothesis is to look at the pattern of investment in 1978. Doing so, it appears that actual investment was lower or about the same as the 1977 level

TABLE 4.16

Actual versus estimated (O.L.S.) and simulated expenditures on Farm Machinery in nominal and constant (1971) dollars and predictions in Canada, East and West.

	CANADA (1.0E+6)	EAST (1.0E+6)	WEST (1.0E+6)
Actual expenditures.			
1978: nominal $	1,287.9	438.3	849.7
constant $	736.5	278.2	483.7
Estimated expenditures.			
1978: nominal $	1,135.7	412.3	668.5
constant $	649.4	261.7	380.6
% error[1]	-11.8%	-5.9%	-21.3%
Simulated expenditures.			
1978: nominal $	1,135.7	412.3	668.5
constant $	649.4	261.7	380.6
% error[1]	-11.8	-5.9%	-21.3%
Predictions.			
1979: nominal $	1,353.8	465.3	850.3
constant $	718.4	268.2	448.5
1980: nominal $	1,507.5	522.7	933.5
constant $	742.4	280.6	456.1
Standard error of the regression. (1971 dollars)			
1978:	37.5	15.7	23.4
1979:	37.5	15.7	23.4
1980:	37.5	15.7	23.4

1. As the deflator is exogenous to the system, the percentage of error is the same either in nominal or constant dollars.

until the end of March. By the end of May, when seeding was completed and more information was available on prices and sales opportunities, investment in the Prairies reached a level 29% higher than in 1977(16). It should also be mentioned that nominal revenue per farm increased by 23% between 1977 and 1978 and farmers may have viewed this surge in income as a good opportunity to invest in farm machinery rather than in other capital assets. Before 1972, farmers were depreciating their assets using the straight line depreciation pattern for income tax purposes. However, since January 1st 1972, any new asset purchaded has to be depreciated using the declining balance method and the rates allowed, for most of the machinery, are either 20% or 30%. Therefore, after 6 or 7 years, the machine is almost fully depreciated and it may then be advantageous to trade in depreciated machines for new ones. Furthermore, since June 25th 1975, the investment tax credit also reduced the cost of machinery by 5% which also gave more incentive to farmers to invest. Another reason that may have pushed investment up in Western Canada in 1978 is that after two years of declining revenue, even in nominal dollars, investment had to be postponed and with this large 23% increase in revenue in 1978, farmers may have suffered from money illusion and invested more than they should have "rationally" done.

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(16)This information comes from Farm Implement and Equipment Sales, Statistics Canada.(Catalogue No. 63-009).

Even with a relatively low standard error of the regression, the summation of forecasted regional sales cannot be said to be different than forecasted sales from Canada's equation. Forecasts for 1979 show a nominal investment level about the same as the actual 1978 level in both East and West as well as in Canada. This implies a decreasing real investment demand. Of course, there is a relative increase between forecasted values in 1978 and 1979, especially in Western Canada, but one should keep in mind that actual 1978 data are used to forecast 1979 levels and past errors in prediction are not taken into account. However, based on 1979 forecasts, a small increase in real farm machinery sales is expected for 1980 in both regions. Eastern sales are expected to go back to the 1978 level whereas Western sales, which increased relatively less in 1980, would not be as high as they were in 1978 in real terms.

Quantity demanded for repair parts

Because the demand for repair parts is a function of endogenous variables in the recursive system, the simulated and estimated (O.L.S.) expenditures are not the same for 1978.

Even if Western expenditures on repair parts were underestimated (see Table 4.17), the model did predict a turning point in 1978 since real sales of repair parts had

TABLE 4.17

Actual versus estimated (O.L.S.) and simulated expenditures on Repair Parts in nominal and constant (1971) dollars and predictions in Canada, East and West.

	CANADA (1.0E+6)	EAST (1.0E+6)	WEST (1.0E+6)
Actual expenditures.			
1978: nominal $	191.9	79.9	111.6
constant $	109.5	50.7	63.5
Estimated expenditures.			
1978: nominal $	190.3	89.3	105.8
constant $	108.8	56.7	60.2
% error[1]	-0.6%	11.8%	-5.2%
Simulated expenditures.			
1978: nominal $	185.8	88.4	105.0
constant $	106.2	56.1	59.7
% error[1]	-3.0	10.8%	-5.9%
Predictions.			
1979: nominal $	214.1	102.8	123.1
constant $	113.6	59.2	64.9
1980: nominal $	240.4	115.1	139.0
constant $	118.4	61.8	67.9

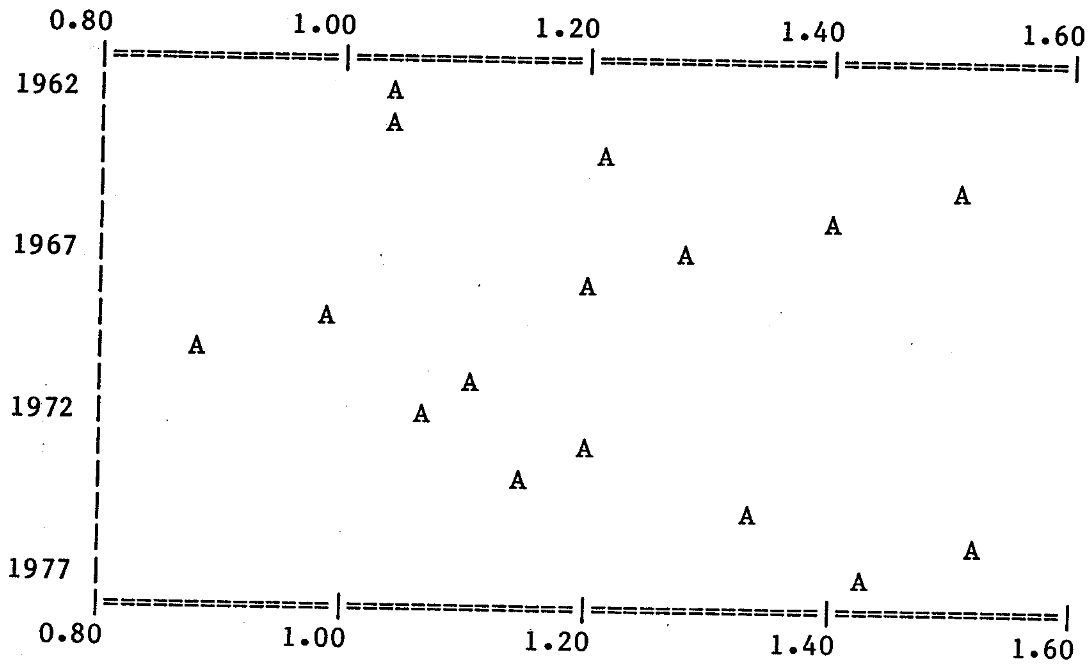
1. As the deflator is exogenous to the system, the percentage of error is the same either in nominal or constant dollars.

been dropping for the last four years and suddenly increased by 16% in 1978. However, Eastern expenditures were expected to increase when they actually remained at the same level shown for the last four years.

Predictions for 1979 and 1980 foresee a slight increase in real expenditures on repair parts in Western Canada of 2.2% and 4.6% respectively. Despite the absence of the forecasted increase for 1978 in Eastern Canada, a raise of 16.9% in the demand level for repair parts is expected in the East for 1979. Assuming this increase actually occurs, the model predicts a more moderate increase of 4.3% in 1980. As for Canadian predictions, the forecasted values for 1979 and 1980 are 9.2% and 9.5% respectively lower than the summation of Eastern and Western forecasts. Of course aggregation bias can explain a part of these differences but another source is that the summation in constant dollars of regional data do not add up to Canadian data for the period under investigation and the sum is consistantly higher. A possible explanation would be that the deflator used, which is the price index of farm machinery, does not correctly reflect the relative weights of Eastern and Western shares on aggregate expenditures for repair parts. One way to verify this hypothesis is to look at the ratio expenditures for repair parts in Eastern versus Western Canada and investment in farm machinery in Eastern versus Western Canada. In order that the price index of farm machinery be

CHART 4.14:

RATIO OF THE RELATIVE WEIGHTS OF EASTERN TO WESTERN CANADA OF REPAIR PARTS AND INVESTMENT IN FARM MACHINERY.



****************************LEGEND*****************************

TIME BOUNDS: 1962 TO 1977

SYMBOL SCALE NAME
A #1 RATIO

****

TROLL COMMAND: .

appropriate to deflate expenditures on repair parts, the ratio of these two ratios should equal one, since it would mean the relative weights in an index for repair parts should be the same as the one used for the farm machinery price index. However, as shown in Chart 4.14, a Canadian index for repair parts should be more biased toward Eastern Canada than the farm machinery price index since the ratio is constantly, and by far, greater than one. Hence using the farm machinery price index as a proxy for repair parts price index was indeed a source of error.

CHAPTER FIVE

SUMMARY AND CONCLUSIONS

Summary

The major models analysing the demand for agricultural durable were summarized in Chapter Two. With the exception of methodology, past investigations were often uniquely specified with few common points. The endogenous variables were often defined differently to test various explanatory variables, estimation methods and functional forms. It is therefore virtually impossible to compare the results directly but some common features were appraised.

The ratio of the price of the input demanded to the price of output and the ratio of the price of the input demanded to the price of labor are two variables common to most stud. They were statistically insignificant with the wrong expected signs in the great majority of these studies. The same conclusions can be drawn from the present study for the farm machinery demand. With respect to the coefficients of adjustment, the stock demand based on a stock adjustment model and the investment demand based on a stock adjustment model provide estimates of the period of time needed to reach the desired level of stock. For farm machinery, this span of time appears to be two years in the United States and five years in Canada. When tractors alone are considered, the time period required to adjust the actual to the optimum/desired stock is about five years in the United States and about eight years or more in Canada. The longer period of adjustment for tractors than for all farm machinery may seem inconsistant since tractors are embodied into "farm machinery" and moreover are the major component of the total. As an explanation for the Canadian case, the following points are noted. It has been shown that the stock of farm machinery in Canada has been relatively constant throughout the sixties and with an increasing physical output and energy utilization, it was assumed that farmers were overcapitalized. It is also reasonable to assume that farmers are overcapitalized in tractors rather than in ploughs or seed drills for instance. Also, the adjustment coefficients appear to be significantly different from one but not from zero or even from being negative which would mean farmers should "disinvest" in order to reach the optimal stock level. The optimum stock of farm machinery is measured in terms of dollars and no specifications are made for the "mix" of different types of machinery. This could possibly explain the shorter period of adjustment for all farm machinery than for tractors alone.

The investment demand based on an investment adjustment model provides an estimate of the time required to adjust the actual investment level to an optimum one. For farm machinery, Heady & Tweeten found that 70% to 80% of the adjustment would occur within one year in the United States. Dhruvarajan's findings for Canada are similar to Heady & Tweeten but Haver & Grove and Brasnett found the adjustment period might be somewhat between two and three years. The present study however suggests the adjustment period would be about five years in Eastern Canada and more than ten years in Western Canada. In Canada as a whole, due to the greater relative weight of the West, the time period approaches ten years. This lack of agreement is certainly due to the different specifications of the present model.

The demand for pesticides has been generally increasing throughout the sixties and seventies in Canada as well as in both Eastern and Western Canada. Both price and revenue elasticities were higher in the East than in the West which indicates potential for more demand instability in Eastern Canada. A higher adjustment coefficient in the East however provides stability to the equation.

Expenditures on petroleum products were increasing slightly but constantly during the sixties and seventies in Western Canada. In the East though, the quantity demanded increased until 1972 and then decreased rapidly to reach a level that is 31% lower in 1977 than in 1972. This behaviour in the East might have been caused by the price effect since the real price behaviour over time was inversely related to Eastern demand for petroleum products. As the West did not react to the variation in the price level, the price elasticity is about three times greater in the East in absolute terms. The "working stock of capital" elasticity, hypothesized to be positive showed a negative sign in Eastern Canada but was positive with a small magnitude in Western Canada. However, two different sources of information provide different tendencies with respect to the trend in the demand for petroleum products after 1972. The negative sign associated with the stock variable in the East should be interpreted carefully. Demand for petroleum products to average farm size (in terms of improved land) and pesticide application per seeded acre was positive in both cases as expected with elasticity coefficients a little smaller in the East. This specific equation performed equally well in both regions and was highly significant with R^2 values higher than 0.98.

The demand for farm machinery in Canada as well as in Eastern and Western Canada shows three major peaks since 1947. The first occured in 1948-53 and a fifteen year interval elapsed before the second occured in 1963-67. The third peak occured ten years later, between 1973-77. The first and second peak reached about the same level of sales before starting to decline and the rate at which sales were declining was about the same as the one at which sales were increasing fifteen years apart. This caused the stock of farm machinery defined as the summation over fifteen years of annual investment to remain constant until 1972. However, since the third peak was only about ten years after the previous one and at a much higher level, the stock of farm machinery increased constantly after 1972. No a priori assumptions were made about the maintenance-stock ratio relationship to farm machinery investment. a positive sign in the East and negative in the West. However, the MSR(-1) elasticities were significantly smaller than one (in absolute terms) in both regions. The relative age of the stock and the revenue variables showed the expected positive sign in all equations. The short run coefficient of elasticity of AGE as well as of REV(-1) were smaller in the East being about 2.1 versus 3.0 for AGE and 0.2 versus 0.6 for REV(-1) in Eastern and Western Canada respectively. The adjustment period seems to be about five years in Eastern Canada and more than ten in Western Canada. This rather long time period in the West could be due to the presence of a trend not adequately picked up by other explanatory variables. Consequently, this trend was embodied into the lagged endogenous variable.

The demand for repair parts differed between Eastern and Western Canada as was expected for the period investigated. Eastern demand has been increasing throughout this period except for the last four years where it was rather constant.

Western demand was relatively constant until 1971, increased until 1974 to reach a level 65% higher than its previous constant level and then dropped by 14% during the last three years. The age of equipment did not show any statistical significance in explaining MSR in Eastern Canada. It was however, significant in the West with an elasticity coefficient of about 0.6. The factor of utilization variable (USE) also showed the expected sign and was statistically significant at the 1% level in both Eastern and Western Canada. Its elasticity coefficient was slightly larger in the West with a value of about 0.45 versus 0.25 in the East. CASH was also statistically significant with the right positive expected sign in both regions and showed a higher elasticity coefficient in Eastern than in Western Canada.

The quantity of pesticides demanded in Canada is expected to continue its upward trend in 1979 and 1980 and attain a level of $108 million in 1971 dollars by 1980. However, this increase in Canadian sales are due exclusively to Western farmers since Eastern sales are expected to remain at their 1978 level which is about $30 million in 1971 dollars. Forecasts for 1979 and 1980 show that petroleum products sales in constant dollars for Canada are expected to be constant at $242 million, a level slightly lower than that of $265 million in 1978. Regional sales are also expected to be stable at a lower level than in 1978.

Farm machinery sales in Canada are expected to decrease slightly in 1979 relative to 1978 but increase again in 1980 at the same level that they reached in 1978 ($740 million of constant (1971) dollars). Eastern and Western farm machinery sales show the same behaviour for 1979 and 1980 relative to 1978. The quantity of repair parts demanded will experience minor increases in both Eastern and Western Canada between 1979 and 1980. However, the relatively constant level will be about 20% higher than the 1978 level in Eastern Canada ($60 million of constant dollars in 1979 and 1980 versus $50 million of constant dollars in 1978). For Western Canada, this constant level will be about the same as in 1978 (about $65 million of 1971 dollars).

Conclusions and limitations

The recursive model proposed in this study performed well when tested empirically. Indeed, each single equation showed high R^2 and high statistical significance for the parameters. Moreover, simulation through the system of equations showed root mean squares percent error to be relatively low for each equation. The turning points in actual demand were therefore adequately picked up by the estimated equations. The test of the predictive power of the model against 1978 actual values was also quite satisfactory.

Such a model could be used to predict the impact of different policies on the demand for a particular input. The investment tax credit which came into effect in 1975 was tested using the present model. Neither a dummy variable, a cash variable nor a price variable all of which were embodied into the farm machinery equation appeared to be significant. It can then be assumed that the income tax subsidy was either saved or spent elsewhere in the economy without affecting significantly the demand for farm machinery.

However, one of the major shortcomings of such time series analyses is the impossibility of adequately taking into account technological change which shifts the production function upward and causes the optimum input ratios to vary over time. The assumption that technological change is adequately reflected in prices may be defendable for the input affected by the change but is unsatisfactory when the effects of substitutes and complements are considered. For instance, machinery and labor may be considered as substitutes to a certain extent and technological improvements on machinery should decrease the need for labor. However, newer and more complex machines require more skill to be operated, hence higher wages and the expenditures on labor does not decrease as much as might be expected. Of course, this fact is embodied into the estimated parameters but there is a bias due to the time adjustment in prices. During a given economic period, the rate of adjustment of the price of labor may be faster than in another economic period and forecasted values will be biased towards the dominating period.

The forecasted results presented in this study must be considered keeping in mind their intrinsic limitations. Indeed, since they are based on a priori assumptions concerning the behaviour of the exogenous variables for 1978 or 1979 on, (see Appendix C), a divergence between actual and hypothesized values might have significant effects on forecasted endogenous variables. However, all exogenous variables utilized in this model can be taken from other existing econometric models and more reliable forecast values can be obtained.

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APPENDIX A

Appendix A

DIFFERENT TYPES OF ADJUSTMENT MODEL

The purpose of this appendix is to present different input demand models which have been most frequently used in agriculture for the last few years. They are all based on a Nerlove type of adjustment model and only the interpretation of the variables changes.

<u>Stock demand based on stock adjustment model</u>

Let S^* be the optimum or desired level of stock for year (t) which is a function of different exogenous variables. This relationship can be expressed as(17):

$$S^* = A0 + Ai*Xi + u \qquad (1)$$

where Xi's are different explanatory variables.

S^* cannot be measured since it is a desired level and not an actual level of stock. It is assumed that farmers will try to reach this optimum level. The difference between actual stock in year (t-1) is a fraction of the difference between the optimum stock in year (t) and the

----

(17)This type of model comes out directly from a Nerlove's partial adjustment model. (See Koutsoyiannis, pp. 310-12).

actual stock in year (t-1). This relation is expressed as:

$$S - S(-1) = k(S^* - S(-1)) \quad (2)$$

with "k" the coefficient of adjustment which is greater than zero and smaller than or equal to one.

Substituting equation (1) into equation (2) yields:

$$S - S(-1) = k(A0 + Ai*Xi + u - S(-1)) \quad (3)$$

Upon rearranging the above equation:

$$S = kA0 + kAi*Xi + (1-k)*S(-1) + ku \quad (4)$$

Equation (4) is the equation used when estimating a stock demand based on a stock adjustment model. One minus the estimated coefficient of the lagged value of the stock gives the value for "k" which , once inversed, indicates how long farmers would take, ceteris paribus, to adjust their existing stock of capital to the optimum or desired one.

Note that the same equation can be estimated in a logarithmic form and the coefficients of the endogenous variables are then the short run coefficients of elasticity which, when divided by the coefficient of adjustment, give an estimate of the long run coefficients of elasticity.

<u>Investment demand based on an investment adjustment model</u>

This type of model is structurally the same as the one described above. One merely has to replace S by I for investment and the same results follow.

<u>Investment demand based on a stock adjustment model</u>

Let "I" be the gross investment in machinery for year (t). By definition, it is the difference between the stock level at the end of the year or at the beginning of the year (t+1) minus the stock level at the beginning of the current year plus the depreciation in year (t) or, mathematically(18):

$$I = S(+1) - S + d*S \tag{5}$$

where "S" is the stock level and "d" the depreciation coefficient.

But, making use of equation (2) above yields:

$$I = k(S^*(+1) - S) + d*S \tag{6}$$

or

$$I = kS^*(+1) + (d-k)*S \tag{7}$$

However, the optimum stock at the end of the year or at the beginning of year (t+1) is a function of the behaviour of the pertinent exogenous variables in year (t) which is expressed:

$$S^*(+1) = A0 + Ai*Xi + u \tag{8}$$

Therefore, substituting (8) into (7) yields:

$$I = kA0 + kAi*Xi + (d-k)*S + ku \tag{9}$$

---

(18)This type of model has been described by Griliches in Harberger pp. 185-87.

which is the investment demand based on a stock adjustment model.

APPENDIX B

Appendix B

ACTUAL VERSUS ESTIMATED AND SIMULATED RESULTS

This Appendix gives the historical values of the four inputs investigated for the period 1962 to 1977 as well as estimated results by ordinary least squares (O.L.S.) and simulated results from the recursive system of equations. Actual, estimated and simulated values for each input and for each regions are also graphed to facilitate the comparison.

TABLE 1:

ESTIMATED DEMAND FOR
PESTICIDES IN CANADA.
('00,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KPESTCAN - ENDOGENOUS

	PEST	SPEST	SPEST_PCER
1962	308.3660	279.8650	-9.2427
1963	322.6820	319.7720	-0.9019
1964	330.9820	344.9970	4.2343
1965	358.6670	392.4630	9.4229
1966	466.4330	428.9370	-8.0389
1967	518.2540	526.5720	1.6049
1968	582.4170	573.8250	-1.4752
1969	497.9060	492.9650	-0.9922
1970	437.2390	446.6640	2.1556
1971	442.3900	436.5300	-1.3246
1972	537.3440	555.6280	3.4025
1973	789.8340	734.1130	-7.0549
1974	714.7900	771.0360	7.8689
1975	689.7440	699.3000	1.3853
1976	766.4280	747.1310	-2.5177
1977	832.2710	800.7730	-3.7846

LEGEND -

PEST: ACTUAL DEMAND.
SPEST: ESTIMATED DEMAND BY ORDINARY LEAST SQUARES.
SPEST_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

TABLE 2:

COMPLETE SIMULATED DEMAND FOR
PESTICIDES IN CANADA.
('00,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KPESTCAN - ENDOGENOUS

	OLIVIER	SOLIVIER	SOLIVIER_PCER
1962	308.3660	279.8650	-9.2427
1963	322.6820	301.3530	-6.6100
1964	330.9820	330.8100	-0.0522
1965	358.6670	392.3670	9.3961
1966	466.4330	453.1580	-2.8459
1967	518.2540	517.3960	-0.1655
1968	582.4170	573.2650	-1.5713
1969	497.9060	488.2940	-1.9304
1970	437.2390	441.3520	0.9408
1971	442.3900	439.0950	-0.7447
1972	537.3440	553.0560	2.9239
1973	789.8340	747.1310	-5.4066
1974	714.7900	745.3100	4.2698
1975	689.7440	717.4580	4.0179
1976	766.4280	765.4100	-0.1329
1977	832.2710	800.1860	-3.8550

LEGEND -

OLIVIER: ACTUAL DEMAND.
SOLIVIER: SIMULATED DEMAND.
SOLIVIER_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

CHART 1:

DEMAND FOR PESTICIDES IN CANADA.
('00,000 OF 1971 DOLLARS)

```
   250.      350.      450.      550.      650.      750.      850.
     |=========|=========|=========|=========|=========|=========|
1962 |  2  A
     |    C 2
     |       2B
     |          A  2
     |                 B C A
1967 |                          2B
     |                               2A
     |                       2A
     |                  2B
     |                  3
1972 |                            ACB
     |                                               B C   A
     |                                             A   C B
     |                                           AB C
     |                                                 B 2
1977 |                                                      2  A
     |=========|=========|=========|=========|=========|=========|
   250.      350.      450.      550.      650.      750.      850.
```

**************************LEGEND****************************

TIME BOUNDS: 1962 TO 1977

SYMBOL	SCALE	NAME
A	#1	KPESTCAN
B	#1	SPEST_KPESTCAN
C	#1	SOLIVIER_KPESTCAN

****

NOTA:

KPEST***: ACTUAL DEMAND FOR PESTICIDES IN THE SPECIFIED REGION.
SPEST_KPEST***: ESTIMATED DEMAND BY O.L.S. FOR PESTICIDES IN THE SPECIFIED REGION.
SOLIVIER_KPEST***: SIMULATED DEMAND FOR PESTICIDES IN THE SPECIFIED REGION.
TROLL COMMAND: .

TABLE 3:

ESTIMATED DEMAND FOR
PESTICIDES IN EASTERN CANADA.
('00,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KPESTEST - ENDOGENOUS

	PEST	SPEST	SPEST_PCER
1962	140.4820	145.9490	3.8919
1963	159.3760	161.3050	1.2099
1964	175.2140	185.0330	5.6042
1965	194.8420	206.4020	5.9328
1966	247.8830	216.1590	-12.7976
1967	277.0940	252.4120	-8.9075
1968	309.3120	275.6450	-10.8847
1969	280.7220	290.0610	3.3265
1970	262.7090	292.7730	11.4436
1971	253.1700	310.4900	22.6411
1972	303.0730	298.2310	-1.5978
1973	434.2220	357.9430	-17.5669
1974	346.5980	378.0640	9.0785
1975	305.2560	322.5410	5.6626
1976	309.5720	291.0410	-5.9861
1977	312.5190	295.5990	-5.4139

LEGEND -

PEST: ACTUAL DEMAND.
SPEST: ESTIMATED DEMAND BY ORDINARY LEAST SQUARES.
SPEST_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

TABLE 4:

COMPLETE SIMULATED DEMAND FOR
PESTICIDES IN EASTERN CANADA.
(`00,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KPESTEST - ENDOGENOUS

	OLIVIER	SOLIVIER	SOLIVIER_PCER
1962	140.4820	145.9490	3.8919
1963	159.3760	163.7020	2.7137
1964	175.2140	186.9570	6.7022
1965	194.8420	211.6400	8.6211
1966	247.8830	223.1760	-9.9669
1967	277.0940	242.3790	-12.5283
1968	309.3120	261.7540	-15.3755
1969	280.7220	271.9440	-3.1270
1970	262.7090	289.2010	10.0842
1971	253.1700	322.2310	27.2785
1972	303.0730	327.3560	8.0121
1973	434.2220	368.7600	-15.0757
1974	346.5980	354.9360	2.4057
1975	305.2560	325.5170	6.6373
1976	309.5720	298.3560	-3.6230
1977	312.5190	291.4150	-6.7527

LEGEND -

OLIVIER: ACTUAL DEMAND.
SOLIVIER: SIMULATED DEMAND.
SOLIVIER_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

CHART 2:

DEMAND FOR PESTICIDES IN EASTERN CANADA.
(`00,000 OF 1971 DOLLARS)

```
  100.    150.    200.    250.    300.    350.    400.    450.
     |=======|=======|=======|=======|=======|=======|=======|
1962 |     A2
     |         3
     |           A 2
     |              A BC
     |                 BC    A
1967 |                     CB    A
     |                         C B    A
     |                          CAB
     |                         A  CB
     |                        A        B C
1972 |                               2   C
     |                                        B C         A
     |                                      A C  B
     |                                A  2
     |                              BC A
1977 |                              2  A
     |=======|=======|=======|=======|=======|=======|=======|
  100.    150.    200.    250.    300.    350.    400.    450.
```

************************LEGEND*************************

TIME BOUNDS: 1962 TO 1977

SYMBOL	SCALE	NAME
A	#1	KPESTEST
B	#1	SPEST_KPESTEST
C	#1	SOLIVIER_KPESTEST

****

NOTA:

KPEST***: ACTUAL DEMAND FOR PESTICIDES IN THE SPECIFIED REGION.
SPEST_KPEST***: ESTIMATED DEMAND BY O.L.S. FOR PESTICIDES IN THE SPECIFIED REGION.
SOLIVIER_KPEST***: SIMULATED DEMAND FOR PESTICIDES IN THE SPECIFIED REGION.
TROLL COMMAND: .

TABLE 5:

ESTIMATED DEMAND FOR
PESTICIDES IN WESTERN CANADA.
('00,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KPESTWST - ENDOGENOUS

	PEST	SPEST	SPEST_PCER
1962	167.8850	141.0860	-15.9627
1963	163.3060	158.8090	-2.7539
1964	155.7690	166.4100	6.8315
1965	163.8250	181.0820	10.5341
1966	218.5500	197.1290	-9.8015
1967	241.1600	247.1290	2.4751
1968	273.1040	271.6480	-0.5330
1969	217.1830	220.6020	1.5743
1970	174.5290	185.0950	6.0535
1971	189.2200	164.2860	-13.1773
1972	234.2710	263.5780	12.5099
1973	355.6120	319.1800	-10.2449
1974	368.1920	392.0080	6.4684
1975	384.4880	405.8790	5.5634
1976	456.8560	438.7190	-3.9700
1977	519.7520	492.5470	-5.2342

LEGEND -

PEST: ACTUAL DEMAND.
SPEST: ESTIMATED DEMAND BY ORDINARY LEAST SQUARES.
SPEST_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

TABLE 6:

COMPLETE SIMULATED DEMAND FOR
PESTICIDES IN WESTERN CANADA.
('00,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KPESTWST - ENDOGENOUS

	OLIVIER	SOLIVIER	SOLIVIER_PCER
1962	167.8850	141.0860	-15.9627
1963	163.3060	139.7070	-14.4507
1964	155.7690	149.5900	-3.9667
1965	163.8250	176.6760	7.8445
1966	218.5500	206.2890	-5.6102
1967	241.1600	238.3910	-1.1483
1968	273.1040	269.6760	-1.2553
1969	217.1830	218.1570	0.4484
1970	174.5290	185.7900	6.4519
1971	189.2200	172.3130	-8.9349
1972	234.2710	251.5270	7.3659
1973	355.6120	331.4800	-6.7858
1974	368.1920	374.8090	1.7971
1975	384.4880	410.5940	6.7897
1976	456.8560	457.3280	0.1034
1977	519.7520	492.8830	-5.1696

LEGEND -

OLIVIER: ACTUAL DEMAND.
SOLIVIER: SIMULATED DEMAND.
SOLIVIER_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

CHART 3:

DEMAND FOR PESTICIDES IN WESTERN CANADA.
(`00,000 OF 1971 DOLLARS)

```
  125.      200.      275.      350.      425.      500.      575.
     |=========|=========|=========|=========|=========|=========|
1962 | 2   A
     | C  2
     |  CA B
     |    A 2
     |         BCA
1967 |              2B
     |                  C2
     |           2B
     |      A2
     |    BC  A
1972 |              A CB
     |                         B C  A
     |                               AC  B
     |                                  A BC
     |                                         B 2
1977 |                                                2   A
     |=========|=========|=========|=========|=========|=========|
  125.      200.      275.      350.      425.      500.      575.
```

**************************LEGEND*****************************

TIME BOUNDS: 1962 TO 1977

SYMBOL	SCALE	NAME
A	#1	KPESTWST
B	#1	SPEST_KPESTWST
C	#1	SOLIVIER_KPESTWST

****

NOTA:

KPEST***: ACTUAL DEMAND FOR PESTICIDES IN THE SPECIFIED REGION.
SPEST_KPEST***: ESTIMATED DEMAND BY O.L.S. FOR PESTICIDES IN THE SPECIFIED REGION.
SOLIVIER_KPEST***: SIMULATED DEMAND FOR PESTICIDES IN THE SPECIFIED REGION.
TROLL COMMAND: .

TABLE 7:

ESTIMATED DEMAND FOR
PETROLEUM PRODUCTS IN CANADA.
('00,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KOILCAN - ENDOGENOUS

	OIL	SOIL	SOIL_PCER
1962	2334.8500	2330.9400	-0.1675
1963	2363.0900	2359.2700	-0.1617
1964	2381.9800	2385.1800	0.1344
1965	2448.0100	2443.7600	-0.1735
1966	2495.7000	2510.9700	0.6121
1967	2571.8600	2554.7500	-0.6653
1968	2603.2200	2603.7300	0.0195
1969	2610.6700	2620.0500	0.3593
1970	2651.0900	2656.7000	0.2119
1971	2647.0800	2640.4500	-0.2505
1972	2693.6800	2692.9200	-0.0282
1973	2750.6100	2753.8400	0.1174
1974	2751.8500	2696.5500	-2.0094
1975	2497.2500	2588.9300	3.6714
1976	2525.2600	2520.8800	-0.1733
1977	2591.1900	2479.0900	-4.3261

LEGEND -

OIL: ACTUAL DEMAND.
SOIL: ESTIMATED DEMAND BY ORDINARY LEAST SQUARES.
SOIL_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

TABLE 8:

COMPLETE SIMULATED DEMAND FOR
PETROLEUM PRODUCTS IN CANADA.
('00,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KOILCAN - ENDOGENOUS

	OLIVIER	SOLIVIER	SOLIVIER_PCER
1962	2334.8500	2315.1000	-0.8460
1963	2363.0900	2341.3000	-0.9222
1964	2381.9800	2373.0900	-0.3732
1965	2448.0100	2450.4100	0.0978
1966	2495.7000	2513.7400	0.7230
1967	2571.8600	2577.1000	0.2037
1968	2603.2200	2620.2000	0.6520
1969	2610.6700	2631.2000	0.7866
1970	2651.0900	2658.1800	0.2677
1971	2647.0800	2630.9000	-0.6114
1972	2693.6800	2694.1800	0.0186
1973	2750.6100	2744.6900	-0.2151
1974	2751.8500	2717.9900	-1.2303
1975	2497.2500	2608.4200	4.4517
1976	2525.2600	2529.6800	0.1750
1977	2591.1900	2472.9600	-4.5625

LEGEND -

OLIVIER: ACTUAL DEMAND.
SOLIVIER: SIMULATED DEMAND.
SOLIVIER_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

CHART 4:

DEMAND FOR PETROLEUM PRODUCTS IN CANADA.
(`00,000 OF 1971 DOLLARS)

```
    2300.       2400.       2500.       2600.       2700.       2800.
     |===========|===========|===========|===========|===========|
1962 | C 2
     |    C BA
     |        C2
     |                B2
     |                      A BC
1967 |                              B 2
     |                                   2 C
     |                                    AB C
     |                                         A2
     |                                       CBA
1972 |                                              3
     |                                                    C2
     |                                               B C   A
     |                       A          B C
     |                          2C
1977 |                    2             A
     |===========|===========|===========|===========|===========|
    2300.       2400.       2500.       2600.       2700.       2800.
```

***************************LEGEND*****************************

TIME BOUNDS: 1962 TO 1977

SYMBOL	SCALE	NAME
A	#1	KOILCAN
B	#1	SOIL_KOILCAN
C	#1	SOLIVIER_KOILCAN

****

NOTA:

KOIL***: ACTUAL DEMAND FOR PETROLEUM PRODUCTS IN THE SPECIFIED REGION.
SOIL_KOIL***: ESTIMATED DEMAND BY O.L.S. FOR PETROLEUM PRODUCTS IN THE SPECIFIED REGION.
SOLIVIER_KOIL***: SIMULATED DEMAND FOR PETROLEUM PRODUCTS IN THE SPECIFIED REGION.
TROLL COMMAND: .

TABLE 9:

ESTIMATED DEMAND FOR
PETROLEUM PRODUCTS IN EASTERN CANADA.
('00,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KOILEST - ENDOGENOUS

	OIL	SOIL	SOIL_PCER
1962	849.3830	845.6350	-0.4412
1963	889.1310	886.6600	-0.2779
1964	883.2530	879.1800	-0.4611
1965	912.8310	920.8230	0.8755
1966	908.4400	926.6360	2.0030
1967	936.7450	946.4300	1.0339
1968	958.3150	961.4860	0.3309
1969	986.0190	968.1430	-1.8129
1970	1017.3200	980.9280	-3.5770
1971	989.6500	964.3030	-2.5612
1972	996.1590	1000.9200	0.4778
1973	978.1360	1001.9500	2.4350
1974	856.0950	884.7610	3.3484
1975	758.0740	779.2540	2.7939
1976	708.4090	710.5720	0.3052
1977	683.4090	666.5630	-2.4650

LEGEND -

OIL: ACTUAL DEMAND.
SOIL: ESTIMATED DEMAND BY ORDINARY LEAST SQUARES.
SOIL_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

TABLE 10:

COMPLETE SIMULATED DEMAND FOR
PETROLEUM PRODUCTS IN EASTERN CANADA.
('00,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KOILEST - ENDOGENOUS

	OLIVIER	SOLIVIER	SOLIVIER_PCER
1962	849.3830	845.7980	-0.4221
1963	889.1310	885.0730	-0.4563
1964	883.2530	875.8510	-0.8380
1965	912.8310	916.5850	0.4113
1966	908.4400	924.6930	1.7891
1967	936.7450	955.5010	2.0023
1968	958.3150	967.2940	0.9370
1969	986.0190	978.9490	-0.7170
1970	1017.3200	982.8640	-3.3867
1971	989.6500	956.6210	-3.3374
1972	996.1590	988.4640	-0.7724
1973	978.1360	987.9260	1.0009
1974	856.0950	881.6940	2.9901
1975	758.0740	779.2990	2.7997
1976	708.4090	706.7360	-0.2362
1977	683.4090	662.9970	-2.9867

LEGEND -

OLIVIER: ACTUAL DEMAND.
SOLIVIER: SIMULATED DEMAND.
SOLIVIER_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

CHART 5:

DEMAND FOR PETROLEUM PRODUCTS IN EASTERN CANADA.
('00,000 OF 1971 DOLLARS)

```
    650.           750.           850.           950.          1050.
     |==============|==============|==============|==============|
1962 |                            2A
     |                                  2A
     |                                 2A
     |                                      ACB
     |                                      A 2
1967 |                                          AB C
     |                                             ABC
     |                                               BCA
     |                                                 2    A
     |                                             CB   A
1972 |                                                  CAB
     |                                                A C B
     |                              A   2
     |               A  2
     |        3
1977 | 2  A
     |==============|==============|==============|==============|
    650.           750.           850.           950.          1050.
```

**************************LEGEND***************************

TIME BOUNDS: 1962 TO 1977

SYMBOL	SCALE	NAME
A	#1	KOILEST
B	#1	SOIL_KOILEST
C	#1	SOLIVIER_KOILEST

****

NOTA:

KOIL***: ACTUAL DEMAND FOR PETROLEUM PRODUCTS IN THE SPECIFIED REGION.
SOIL_KOIL***: ESTIMATED DEMAND BY O.L.S. FOR PETROLEUM PRODUCTS IN THE SPECIFIED REGION.
SOLIVIER_KOIL***: SIMULATED DEMAND FOR PETROLEUM PRODUCTS IN THE SPECIFIED REGION.
TROLL COMMAND: .

TABLE 11:

ESTIMATED DEMAND FOR
PETROLEUM PRODUCTS IN WESTERN CANADA.
('00,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KOILWST - ENDOGENOUS

	OIL	SOIL	SOIL_PCER
1962	1484.5300	1475.5100	-0.6070
1963	1480.3000	1485.4600	0.3492
1964	1499.3900	1493.4000	-0.3993
1965	1536.7100	1532.4400	-0.2775
1966	1585.9400	1598.9200	0.8179
1967	1631.9500	1633.2800	0.0818
1968	1644.7400	1639.2300	-0.3349
1969	1624.5200	1625.2900	0.0469
1970	1634.7800	1648.5200	0.8404
1971	1657.4300	1642.2700	-0.9149
1972	1695.5400	1699.0300	0.2058
1973	1770.7900	1788.6400	1.0080
1974	1916.5500	1851.4200	-3.3980
1975	1754.2100	1818.4600	3.6628
1976	1834.3900	1830.8100	-0.1950
1977	1928.8900	1860.6600	-3.5369

LEGEND -

OIL: ACTUAL DEMAND.
SOIL: ESTIMATED DEMAND BY ORDINARY LEAST SQUARES.
SOIL_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

TABLE 12:

COMPLETE SIMULATED DEMAND FOR
PETROLEUM PRODUCTS IN WESTERN CANADA.
('00,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KOILWST - ENDOGENOUS

	OLIVIER	SOLIVIER	SOLIVIER_PCER
1962	1484.5300	1454.8500	-1.9988
1963	1480.3000	1468.2100	-0.8164
1964	1499.3900	1490.9700	-0.5616
1965	1536.7100	1543.0200	0.4105
1966	1585.9400	1588.3000	0.1486
1967	1631.9500	1625.6300	-0.3873
1968	1644.7400	1632.4500	-0.7473
1969	1624.5200	1623.2100	-0.0807
1970	1634.7800	1658.0000	1.4202
1971	1657.4300	1630.0300	-1.6531
1972	1695.5400	1707.9800	0.7337
1973	1770.7900	1773.9600	0.1789
1974	1916.5500	1850.4700	-3.4479
1975	1754.2100	1826.0500	4.0955
1976	1834.3900	1828.9200	-0.2982
1977	1928.8900	1851.0700	-4.0340

LEGEND -

OLIVIER: ACTUAL DEMAND.
SOLIVIER: SIMULATED DEMAND.
SOLIVIER_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

CHART 6:

DEMAND FOR PETROLEUM PRODUCTS IN WESTERN CANADA.
(`00,000 OF 1971 DOLLARS)

```
      1450.      1550.      1650.      1750.      1850.      1950.
         |===========|===========|===========|===========|===========|
   1962  |C BA
         | C 2
         |    2A
         |         2C
         |               ACB
   1967  |                   C2
         |                    C2
         |                   3
         |                    A BC
         |                    CB A
   1972  |                          ABC
         |                                  AC B
         |                                           2       A
         |                                 A      BC
         |                                         C2
   1977  |                                            CB      A
         |===========|===========|===========|===========|===========|
      1450.      1550.      1650.      1750.      1850.      1950.
```

**************************LEGEND****************************

TIME BOUNDS: 1962 TO 1977

SYMBOL SCALE NAME
A #1 KOILWST
B #1 SOIL_KOILWST
C #1 SOLIVIER_KOILWST

****

NOTA:

KOIL***: ACTUAL DEMAND FOR PETROLEUM PRODUCTS IN THE SPECIFIED REGION.
SOIL_KOIL***: ESTIMATED DEMAND BY O.L.S. FOR PETROLEUM PRODUCTS IN THE SPECIFIED REGION.
SOLIVIER_KOIL***: SIMULATED DEMAND FOR PETROLEUM PRODUCTS IN THE SPECIFIED REGION.
TROLL COMMAND: .

TABLE 13:

ESTIMATED DEMAND FOR
FARM MACHINERY IN CANADA.
('00,000,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KMACHCAN - ENDOGENOUS

	INV	SINV	SINV_PCER
1962	3.1529	3.3941	7.6522
1963	3.6713	3.8270	4.2417
1964	4.0531	4.0464	-0.1649
1965	4.4751	4.1577	-7.0912
1966	4.8170	4.2798	-11.1518
1967	4.8315	4.4733	-7.4145
1968	3.7748	4.2672	13.0449
1969	3.6071	3.3889	-6.0476
1970	2.8687	3.4430	20.0205
1971	3.2616	3.2819	0.6236
1972	4.0526	3.8467	-5.0791
1973	5.3210	5.1098	-3.9695
1974	5.9019	6.2982	6.7136
1975	6.9145	6.8740	-0.5858
1976	7.6229	7.4288	-2.5453
1977	7.0805	7.2893	2.9493

LEGEND -

INV: ACTUAL DEMAND.
SINV: ESTIMATED DEMAND BY ORDINARY LEAST SQUARES.
SINV_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

TABLE 14:

COMPLETE SIMULATED DEMAND FOR
FARM MACHINERY IN CANADA.
('00,000,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KMACHCAN - ENDOGENOUS

	OLIVIER	SOLIVIER	SOLIVIER_PCER
1962	3.1529	3.3941	7.6522
1963	3.6713	3.9840	8.5199
1964	4.0531	4.2147	3.9889
1965	4.4751	4.1502	-7.2597
1966	4.8170	3.9635	-17.7186
1967	4.8315	3.9442	-18.3655
1968	3.7748	3.9365	4.2829
1969	3.6071	3.9053	8.2665
1970	2.8687	3.7814	31.8179
1971	3.2616	3.7333	14.4607
1972	4.0526	3.8526	-4.9333
1973	5.3210	4.6200	-13.1741
1974	5.9019	5.7435	-2.6851
1975	6.9145	6.9521	0.5445
1976	7.6229	7.6042	-0.2451
1977	7.0805	7.2753	2.7516

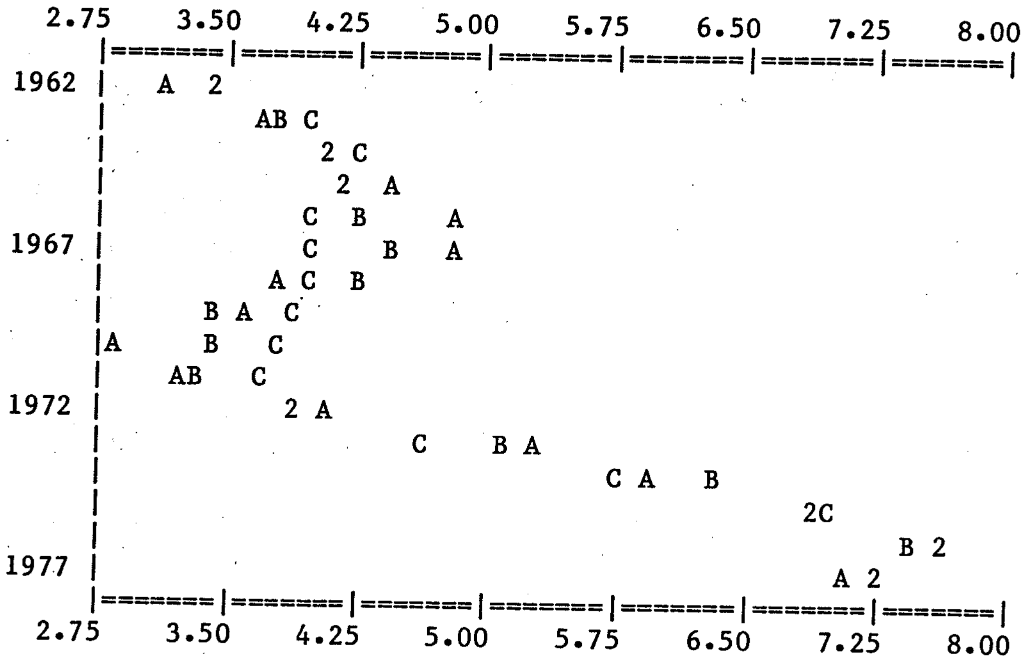
LEGEND -

OLIVIER: ACTUAL DEMAND.
SOLIVIER: SIMULATED DEMAND.
SOLIVIER_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

CHART 7:

DEMAND FOR FARM MACHINERY IN CANADA.
('00,000,000 OF 1971 DOLLARS)



************************LEGEND*************************

TIME BOUNDS: 1962 TO 1977

SYMBOL	SCALE	NAME
A	#1	KMACHCAN
B	#1	SINV_KMACHCAN
C	#1	SOLIVIER_KMACHCAN

****

NOTA:

KMACH***: ACTUAL DEMAND FOR FARM MACHINERY IN THE SPECIFIED REGION.
SINV_KMACH***: ESTIMATED DEMAND BY O.L.S. FOR FARM MACHINERY IN THE SPECIFIED REGION.
SOLIVIER_KMACH***: SIMULATED DEMAND FOR FARM MACHINERY IN THE SPECIFIED REGION.
TROLL COMMAND: .

TABLE 15:

ESTIMATED DEMAND FOR
FARM MACHINERY IN EASTERN CANADA.
('00,000,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KMACHEST - ENDOGENOUS

	INV	SINV	SINV_PCER
1962	1.1964	1.2236	2.2673
1963	1.3523	1.3107	-3.0754
1964	1.4119	1.4339	1.5563
1965	1.4202	1.4520	2.2390
1966	1.6678	1.4692	-11.9084
1967	1.8606	1.7218	-7.4592
1968	1.5363	1.7788	15.7791
1969	1.7193	1.5229	-11.4257
1970	1.5017	1.7539	16.7982
1971	1.5094	1.6541	9.5815
1972	1.8236	1.7707	-2.9010
1973	2.1373	2.1581	0.9712
1974	2.5341	2.5173	-0.6640
1975	2.8368	2.8281	-0.3047
1976	2.8094	2.8598	1.7941
1977	2.8111	2.6735	-4.8943

LEGEND -

INV: ACTUAL DEMAND.
SINV: ESTIMATED DEMAND BY ORDINARY LEAST SQUARES.
SINV_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

TABLE 16:

COMPLETE SIMULATED DEMAND FOR
FARM MACHINERY IN EASTERN CANADA.
('00,000,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KMACHEST - ENDOGENOUS

	OLIVIER	SOLIVIER	SOLIVIER_PCER
1962	1.1964	1.2236	2.2673
1963	1.3523	1.3935	3.0448
1964	1.4119	1.4949	5.8744
1965	1.4202	1.4549	2.4415
1966	1.6678	1.4474	-13.2157
1967	1.8606	1.5441	-17.0067
1968	1.5363	1.5971	3.9543
1969	1.7193	1.6989	-1.1863
1970	1.5017	1.8438	22.7817
1971	1.5094	1.9039	26.1339
1972	1.8236	1.8095	-0.7736
1973	2.1373	1.9732	-7.6798
1974	2.5341	2.4145	-4.7188
1975	2.8368	2.7748	-2.1858
1976	2.8094	2.8859	2.7214
1977	2.8111	2.7782	-1.1700

LEGEND -

OLIVIER: ACTUAL DEMAND.
SOLIVIER: SIMULATED DEMAND.
SOLIVIER_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

CHART 8:

DEMAND FOR FARM MACHINERY IN EASTERN CANADA.
('00,000,000 OF 1971 DOLLARS)

```
   1.00           1.50           2.00           2.50           3.00
     |==============|==============|==============|==============|
1962 |    A2
     |       B AC
     |          AB C
     |           A2
     |           CB     A
1967 |              C     B   A
     |              A C    B
     |              B    CA
     |             A       B C
     |             A    B      C
1972 |                     BCA
     |                           C    AB
     |                                        C   2
     |                                                   C 2
     |                                                    A BC
1977 |                                                B  CA
     |==============|==============|==============|==============|
   1.00           1.50           2.00           2.50           3.00
```

```
**************************LEGEND****************************

TIME BOUNDS: 1962 TO 1977

SYMBOL SCALE NAME
   A     #1   KMACHEST
   B     #1   SINV_KMACHEST
   C     #1   SOLIVIER_KMACHEST

************************************************************
```

NOTA:

KMACH***: ACTUAL DEMAND FOR FARM MACHINERY IN THE SPECIFIED REGION.
SINV_KMACH***: ESTIMATED DEMAND BY O.L.S. FOR FARM MACHINERY IN THE SPECIFIED REGION.
SOLIVIER_KMACH***: SIMULATED DEMAND FOR FARM MACHINERY IN THE SPECIFIED REGION.
TROLL COMMAND: .

TABLE 17:

ESTIMATED DEMAND FOR
FARM MACHINERY IN WESTERN CANADA.
('00,000,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KMACHWST - ENDOGENOUS

	INV	SINV	SINV_PCER
1962	1.9926	2.1369	7.2445
1963	2.3649	2.5635	8.3970
1964	2.6747	2.5935	-3.0351
1965	3.0860	2.7712	-10.2006
1966	3.2084	2.8781	-10.2934
1967	3.0306	2.8436	-6.1713
1968	2.2841	2.5993	13.8004
1969	1.9335	1.9234	-0.5271
1970	1.4109	1.6390	16.1712
1971	1.8080	1.6476	-8.8737
1972	2.3062	2.3066	0.0183
1973	3.2676	3.1703	-2.9749
1974	3.6342	3.9003	7.3225
1975	4.4400	4.4012	-0.8720
1976	4.9832	4.8965	-1.7406
1977	4.4184	4.5721	3.4789

LEGEND -

INV: ACTUAL DEMAND.
SINV: ESTIMATED DEMAND BY ORDINARY LEAST SQUARES.
SINV_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

TABLE 18:

COMPLETE SIMULATED DEMAND FOR
FARM MACHINERY IN WESTERN CANADA.
('00,000,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KMACHWST - ENDOGENOUS

	OLIVIER	SOLIVIER	SOLIVIER_PCER
1962	1.9926	2.1369	7.2445
1963	2.3649	2.6234	10.9316
1964	2.6747	2.7664	3.4284
1965	3.0860	2.7370	-11.3093
1966	3.2084	2.5674	-19.9784
1967	3.0306	2.5046	-17.3559
1968	2.2841	2.4760	8.4033
1969	1.9335	2.3294	20.4754
1970	1.4109	1.9693	39.5822
1971	1.8080	1.7864	-1.1921
1972	2.3062	2.0092	-12.8772
1973	3.2676	2.8024	-14.2343
1974	3.6342	3.6897	1.5278
1975	4.4400	4.6084	3.7932
1976	4.9832	5.0307	0.9521
1977	4.4184	4.5465	2.8978

LEGEND -

OLIVIER: ACTUAL DEMAND.
SOLIVIER: SIMULATED DEMAND.
SOLIVIER_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

CHART 9:

DEMAND FOR FARM MACHINERY IN WESTERN CANADA.
(`00,000,000 OF 1971 DOLLARS)

```
   1.25      2.00      2.75      3.50      4.25      5.00      5.75
     |=========|=========|=========|=========|=========|=========|
1962 |         A 2
     |              A  2
     |                BAC
     |                   2   A
     |                 C   B   A
1967 |                C   B  A
     |             A C B
     |        2    C
     | A  B    C
     |    B 2
1972 |         C   2
     |                    C    BA
     |                               AC B
     |                                        BA C
     |                                               B2
1977 |                                        A 2
     |=========|=========|=========|=========|=========|=========|
   1.25      2.00      2.75      3.50      4.25      5.00      5.75
```

**************************LEGEND****************************

TIME BOUNDS: 1962 TO 1977

SYMBOL	SCALE	NAME
A	#1	KMACHWST
B	#1	SINV_KMACHWST
C	#1	SOLIVIER_KMACHWST

****

NOTA:

KMACH***: ACTUAL DEMAND FOR FARM MACHINERY IN THE SPECIFIED REGION.
SINV_KMACH***: ESTIMATED DEMAND BY O.L.S. FOR FARM MACHINERY IN THE SPECIFIED REGION.
SOLIVIER_KMACH***: SIMULATED DEMAND FOR FARM MACHINERY IN THE SPECIFIED REGION.
TROLL COMMAND: .

TABLE 19:

ESTIMATED DEMAND FOR
REPAIR PARTS IN CANADA.
('00,000,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KREPCAN - ENDOGENOUS

	REP	SREP	SREP_PCER
1962	0.5828	0.6374	9.3676
1963	0.6447	0.6289	-2.4416
1964	0.6589	0.6553	-0.5586
1965	0.6706	0.6733	0.4031
1966	0.7162	0.7041	-1.6888
1967	0.6929	0.7082	2.1989
1968	0.6939	0.7092	2.2076
1969	0.6911	0.6755	-2.2549
1970	0.6687	0.6964	4.1441
1971	0.7681	0.7261	-5.4692
1972	0.8478	0.8518	0.4740
1973	1.0034	0.9806	-2.2738
1974	1.0933	1.1102	1.5417
1975	1.0308	1.0921	5.9489
1976	1.0400	0.9838	-5.3969
1977	1.0183	0.9599	-5.7376

LEGEND -

REP: ACTUAL DEMAND.
SREP: ESTIMATED DEMAND BY ORDINARY LEAST SQUARES.
SREP_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

TABLE 20:

COMPLETE SIMULATED DEMAND FOR
REPAIR PARTS IN CANADA.
('00,000,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KREPCAN - ENDOGENOUS

	OLIVIER	SOLIVIER	SOLIVIER_PCER
1962	0.5828	0.6326	8.5450
1963	0.6447	0.6231	-3.3394
1964	0.6589	0.6526	-0.9579
1965	0.6706	0.6761	0.8281
1966	0.7162	0.7153	-0.1334
1967	0.6929	0.7191	3.7830
1968	0.6939	0.7149	3.0253
1969	0.6911	0.6792	-1.7133
1970	0.6687	0.6871	2.7464
1971	0.7681	0.7098	-7.5880
1972	0.8478	0.8458	-0.2353
1973	1.0034	0.9796	-2.3792
1974	1.0933	1.1034	0.9175
1975	1.0308	1.1086	7.5550
1976	1.0400	0.9843	-5.3507
1977	1.0183	0.9356	-8.1210

LEGEND -

OLIVIER: ACTUAL DEMAND.
SOLIVIER: SIMULATED DEMAND.
SOLIVIER_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

CHART 10:

DEMAND FOR REPAIR PARTS IN CANADA.
('00,000,000 OF 1971 DOLLARS)

```
       0.55      0.65      0.75      0.85      0.95      1.05      1.15
          |=========|=========|=========|=========|=========|=========|
     1962 |  A    CB
          |      CBA
          |         C2
          |           2C
          |              B 2
     1967 |             A BC
          |             A 2
          |            2A
          |           A CB
          |               C B   A
     1972 |                            3
          |                                        2 A
          |                                                 ACB
          |                                             A     B C
          |                                        2     A
     1977 |                                    C B     A
          |=========|=========|=========|=========|=========|=========|
       0.55      0.65      0.75      0.85      0.95      1.05      1.15
```

**************************LEGEND****************************

TIME BOUNDS: 1962 TO 1977

SYMBOL	SCALE	NAME
A	#1	KREPCAN
B	#1	SREP_KREPCAN
C	#1	SOLIVIER_KREPCAN

****

NOTA:

KREP***: ACTUAL DEMAND FOR REPAIR PARTS IN THE SPECIFIED REGION.
SREP_KREP***: ESTIMATED DEMAND BY O.L.S. FOR REPAIR PARTS IN THE SPECIFIED REGION.
SOLIVIER_KREP***: SIMULATED DEMAND FOR REPAIR PARTS IN THE SPECIFIED REGION.
TROLL COMMAND: .

TABLE 21:

ESTIMATED DEMAND FOR
REPAIR PARTS IN EASTERN CANADA.
('00,000,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KREPEST - ENDOGENOUS

	REP	SREP	SREP_PCER
1962	0.2272	0.2513	10.6292
1963	0.2437	0.2595	6.4751
1964	0.2603	0.2507	-3.6753
1965	0.2773	0.2716	-2.0481
1966	0.3067	0.2958	-3.5469
1967	0.3099	0.2925	-5.6175
1968	0.3138	0.3178	1.2677
1969	0.3259	0.3439	5.5231
1970	0.3266	0.3557	8.9037
1971	0.3751	0.3354	-10.5884
1972	0.3953	0.3898	-1.3915
1973	0.4456	0.4709	5.6824
1974	0.5104	0.4965	-2.7183
1975	0.5029	0.5012	-0.3352
1976	0.4942	0.5013	1.4369
1977	0.4967	0.4957	-0.1915

LEGEND -

REP: ACTUAL DEMAND.
SREP: ESTIMATED DEMAND BY ORDINARY LEAST SQUARES.
SREP_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

TABLE 22:

COMPLETE SIMULATED DEMAND FOR
REPAIR PARTS IN EASTERN CANADA.
('00,000,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KREPEST - ENDOGENOUS

	OLIVIER	SOLIVIER	SOLIVIER_PCER
1962	0.2272	0.2508	10.3837
1963	0.2437	0.2590	6.2750
1964	0.2603	0.2499	-3.9844
1965	0.2773	0.2731	-1.5209
1966	0.3067	0.3006	-1.9800
1967	0.3099	0.2961	-4.4600
1968	0.3138	0.3151	0.4150
1969	0.3259	0.3401	4.3563
1970	0.3266	0.3463	6.0337
1971	0.3751	0.3295	-12.1584
1972	0.3953	0.3941	-0.2943
1973	0.4456	0.4792	7.5468
1974	0.5104	0.5042	-1.2069
1975	0.5029	0.5064	0.6978
1976	0.4942	0.5023	1.6488
1977	0.4967	0.4958	-0.1726

LEGEND -

OLIVIER: ACTUAL DEMAND.
SOLIVIER: SIMULATED DEMAND.
SOLIVIER_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

CHART 11:

DEMAND FOR REPAIR PARTS IN EASTERN CANADA.
('00,000,000 OF 1971 DOLLARS)

```
   0.200   0.250   0.300   0.350   0.400   0.450   0.500   0.550
     |=======|=======|=======|=======|=======|=======|=======|=======|
1962 |   A   2
     |      A CB
     |       2 A
     |          B2
     |              BCA
1967 |              2  A
     |                 2B
     |                   A CB
     |                   A  C B
     |                    CB     A
1972 |                             B2
     |                                      A   B C
     |                                              B CA
     |                                               2C
     |                                              A2
1977 |                                              3
     |=======|=======|=======|=======|=======|=======|=======|=======|
   0.200   0.250   0.300   0.350   0.400   0.450   0.500   0.550
```

************************LEGEND*************************

TIME BOUNDS: 1962 TO 1977

SYMBOL	SCALE	NAME
A	#1	KREPEST
B	#1	SREP_KREPEST
C	#1	SOLIVIER_KREPEST

****

NOTA:

KREP***: ACTUAL DEMAND FOR REPAIR PARTS IN THE SPECIFIED REGION.
SREP_KREP***: ESTIMATED DEMAND BY O.L.S. FOR REPAIR PARTS IN THE SPECIFIED REGION.
SOLIVIER_KREP***: SIMULATED DEMAND FOR REPAIR PARTS IN THE SPECIFIED REGION.
TROLL COMMAND: .

TABLE 23:

ESTIMATED DEMAND FOR
REPAIR PARTS IN WESTERN CANADA.
('00,000,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KREPWST - ENDOGENOUS

	REP	SREP	SREP_PCER
1962	0.3624	0.3992	10.1383
1963	0.4092	0.3836	-6.2593
1964	0.4052	0.4096	1.0919
1965	0.4007	0.4026	0.4745
1966	0.4217	0.4089	-3.0243
1967	0.3937	0.4108	4.3402
1968	0.3896	0.3931	0.8863
1969	0.3738	0.3507	-6.1776
1970	0.3513	0.3652	3.9673
1971	0.4069	0.4084	0.3720
1972	0.4691	0.4809	2.5039
1973	0.5662	0.5411	-4.4288
1974	0.6361	0.6371	0.1512
1975	0.5919	0.6255	5.6725
1976	0.5753	0.5461	-5.0752
1977	0.5491	0.5365	-2.2891

LEGEND -

REP: ACTUAL DEMAND.
SREP: ESTIMATED DEMAND BY ORDINARY LEAST SQUARES.
SREP_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

TABLE 24:

COMPLETE SIMULATED DEMAND FOR
REPAIR PARTS IN WESTERN CANADA.
('00,000,000 OF 1971 DOLLARS)

SIMULATION OUTPUT BY VARIABLE

KREPWST - ENDOGENOUS

	OLIVIER	SOLIVIER	SOLIVIER_PCER
1962	0.3624	0.3946	8.8741
1963	0.4092	0.3803	-7.0728
1964	0.4052	0.4073	0.5185
1965	0.4007	0.4045	0.9560
1966	0.4217	0.4143	-1.7445
1967	0.3937	0.4181	6.2139
1968	0.3896	0.3977	2.0806
1969	0.3738	0.3524	-5.7257
1970	0.3513	0.3606	2.6607
1971	0.4069	0.3932	-3.3564
1972	0.4691	0.4750	1.2534
1973	0.5662	0.5393	-4.7438
1974	0.6361	0.6278	-1.3135
1975	0.5919	0.6323	6.8192
1976	0.5753	0.5426	-5.6863
1977	0.5491	0.5190	-5.4819

LEGEND -

OLIVIER: ACTUAL DEMAND.
SOLIVIER: SIMULATED DEMAND.
SOLIVIER_PCER: PERCENTAGE OF ERROR.

TROLL COMMAND: .

CHART 12:

DEMAND FOR REPAIR PARTS IN WESTERN CANADA.
('00,000,000 OF 1971 DOLLARS)

```
   0.350   0.400   0.450   0.500   0.550   0.600   0.650   0.700
     |=======|=======|=======|=======|=======|=======|=======|
1962 | A    CB
     |    2   A
     |        2B
     |       2C
     |        BCA
1967 |      A  BC
     |     ABC
     2   A
     A 2
     |      C 2
1972 |                  ACB
     |                             CB   A
     |                                           C 2
     |                                      A    BC
     |                              2    A
1977 |                          C  B A
     |=======|=======|=======|=======|=======|=======|=======|
   0.350   0.400   0.450   0.500   0.550   0.600   0.650   0.700
```

************************LEGEND*************************

TIME BOUNDS: 1962 TO 1977

SYMBOL	SCALE	NAME
A	#1	KREPWST
B	#1	SREP_KREPWST
C	#1	SOLIVIER_KREPWST

****

NOTA:

KREP***: ACTUAL DEMAND FOR REPAIR PARTS IN THE SPECIFIED REGION.
SREP_KREP***: ESTIMATED DEMAND BY O.L.S. FOR REPAIR PARTS IN THE SPECIFIED REGION.
SOLIVIER_KREP***: SIMULATED DEMAND FOR REPAIR PARTS IN THE SPECIFIED REGION.
TROLL COMMAND: .

APPENDIX C

Appendix C

THE EXOGENOUS VARIABLES OF THE MODEL

All the exogenous variables of the system of equations presented in this study are presented in this Appendix. Each chart shows the actual behavior of the variables for the period 1962 to 1977 or 1978 and the proxies for the period 1977 or 1978 to 1980.

CHART 1:

PRICE INDEX OF PESTICIDES.
(1971 = 100.)

```
          80.        120.       160.       200.       240.       280.       320.
           |==========|==========|==========|==========|==========|==========|
     1962  |A
           |A
           | A
           |A
           | A
     1967  | A
           |  A
           |   A
           |   A
           |    A
     1972  |      A
           |      A
           |                        A
           |                                         A
           |                                           A
     1977  |                                            A
           |                                                A
           |                                                  A
           |                                                     A
           |==========|==========|==========|==========|==========|==========|
          80.        120.       160.       200.       240.       280.       320.
```

**************************LEGEND****************************

TIME BOUNDS: 1962 TO 1980

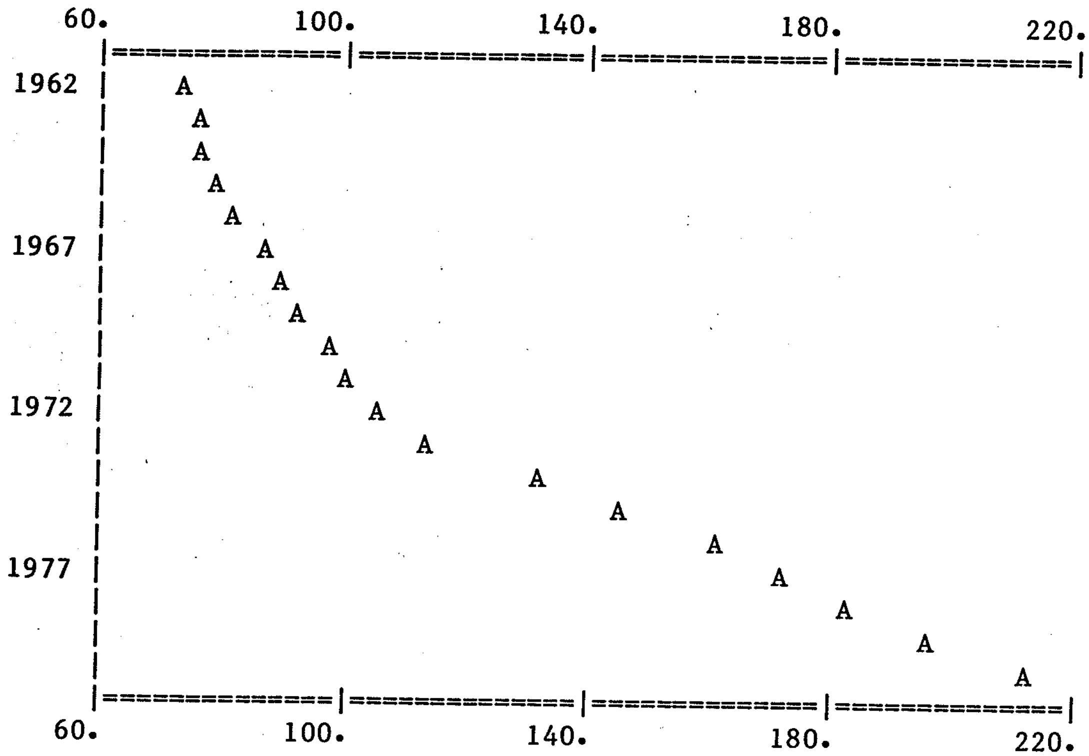
SYMBOL SCALE NAME
   A   #1   PIPEST

****

TROLL COMMAND: .

CHART 2:

GROSS NATIONAL EXPENDITURES IMPLICIT PRICE INDEX.
(1971 = 100.)



**************************LEGEND*****************************

TIME BOUNDS: 1962 TO 1980

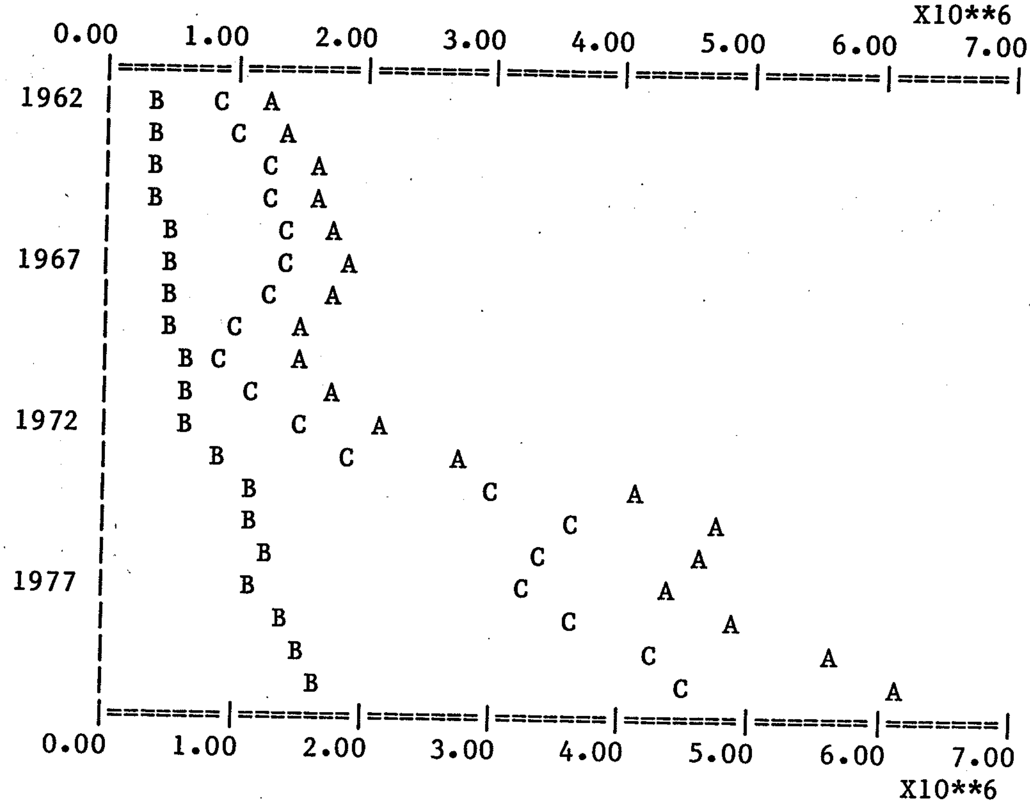
SYMBOL SCALE NAME
A #1 GNECAN

****

TROLL COMMAND: .

CHART 3:

FARM CASH RECEIPTS FROM CROPS BY REGIONS.
('000 OF NOMINAL DOLLARS)



************************LEGEND*************************

TIME BOUNDS: 1962 TO 1980

SYMBOL	SCALE	NAME
A	#1	FCRCCAN
B	#1	FCRCEST
C	#1	FCRCWST

****

NOTA:
SYMBOLS A, B AND C REFLECT CANADA, EAST AND WEST RESPECTIVELY.
TROLL COMMAND: .

CHART 4:

PRICE DEFLATOR OF GROSS PRIVATE BUSINESS PRODUCTS.
(1971 = 100.)

```
      70.     95.     120.    145.    170.    195.    220.    245.
       |=======|=======|=======|=======|=======|=======|=======|
  1962 |A
       |A
       | A
       |   A
       |    A
  1967 |    A
       |     A
       |      A
       |       A
       |         A
  1972 |          A
       |             A
       |                   A
       |                        A
       |                             A
  1977 |                                 A
       |                                      A
       |                                           A
       |                                                 A
       |=======|=======|=======|=======|=======|=======|=======|
      70.     95.     120.    145.    170.    195.    220.    245.
```

************************LEGEND*************************

TIME BOUNDS: 1962 TO 1980

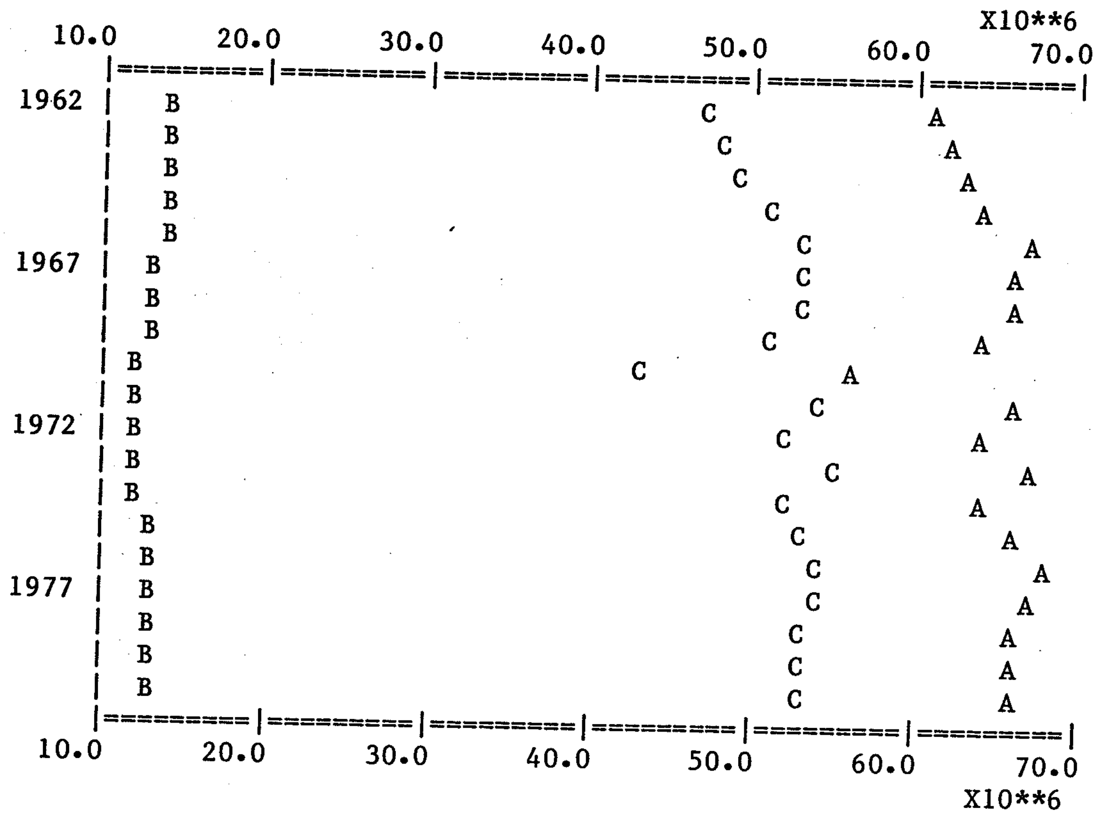
SYMBOL SCALE NAME
A #1 PGPP

****

TROLL COMMAND: .

CHART 5:

'TOTAL ESTIMATED ACREAGE UNDER CROPS BY REGIONS.
(ACRES)



*************************LEGEND***************************

TIME BOUNDS: 1962 TO 1980

SYMBOL	SCALE	NAME
A	#1	AREACAN
B	#1	AREAEST
C	#1	AREAWST

****

NOTA:
SYMBOLS A, B AND C REFLECT CANADA, EAST AND WEST RESPECTIVELY.
TROLL COMMAND: .

CHART 6:

PRICE INDEX OF PETROLEUM PRODUCTS BY REGIONS.
(1971 = 100.)

```
     75.    100.    125.    150.    175.    200.    225.    250.
      |=======|=======|=======|=======|=======|=======|=======|
 1962 | BAC
      |B AC
      | B 2
      |  2C
      |   3
 1967 |   2B
      |    B2
      |     B2
      |      3
      |       3
 1972 |       B2
      |         B2
      |             C A B
      |                     C A B
      |                            C A B
 1977 |                                 C A B
      |                                    C A  B
      |                                          C A  B
      |                                                C A   B
      |=======|=======|=======|=======|=======|=======|=======|
     75.    100.    125.    150.    175.    200.    225.    250.
```

************************LEGEND*************************

TIME BOUNDS: 1962 TO 1980

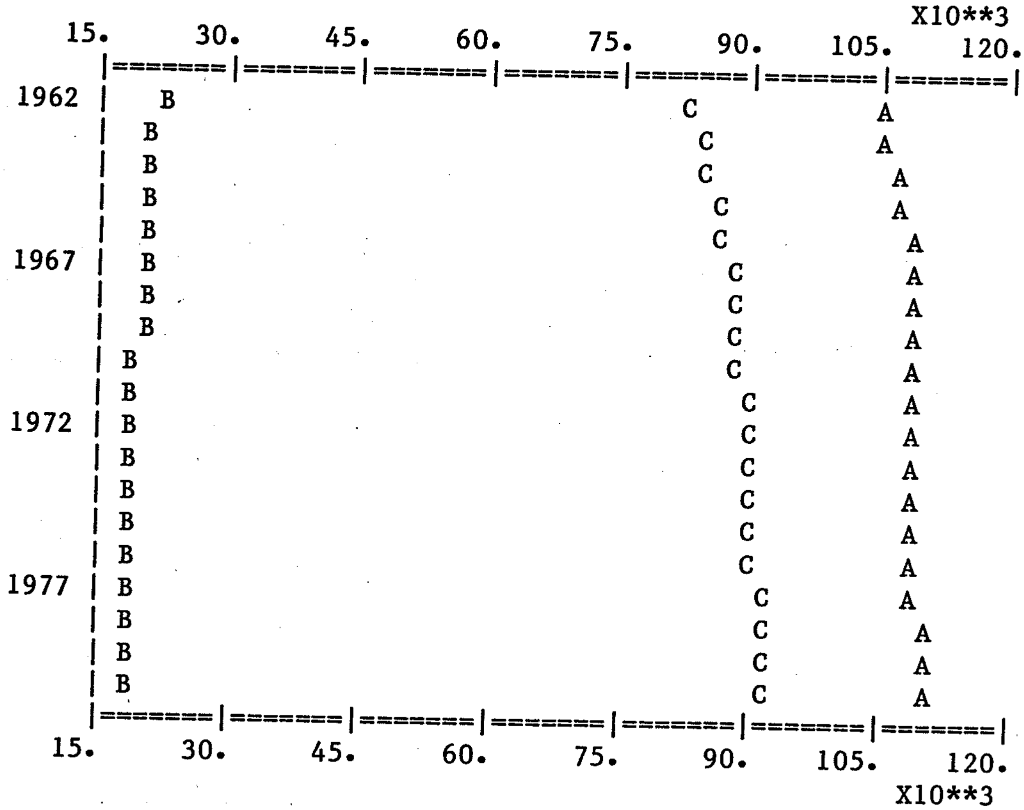
SYMBOL	SCALE	NAME
A	#1	PIOILCAN
B	#1	PIOILEST
C	#1	PIOILWST

****

NOTA:
SYMBOLS A, B AND C REFLECT CANADA, EAST AND WEST RESPECTIVELY.
TROLL COMMAND: .

CHART 7:

TOTAL IMPROVED ACRES BY REGIONS.
('000 ACRES)



************************LEGEND*************************

TIME BOUNDS: 1962 TO 1980

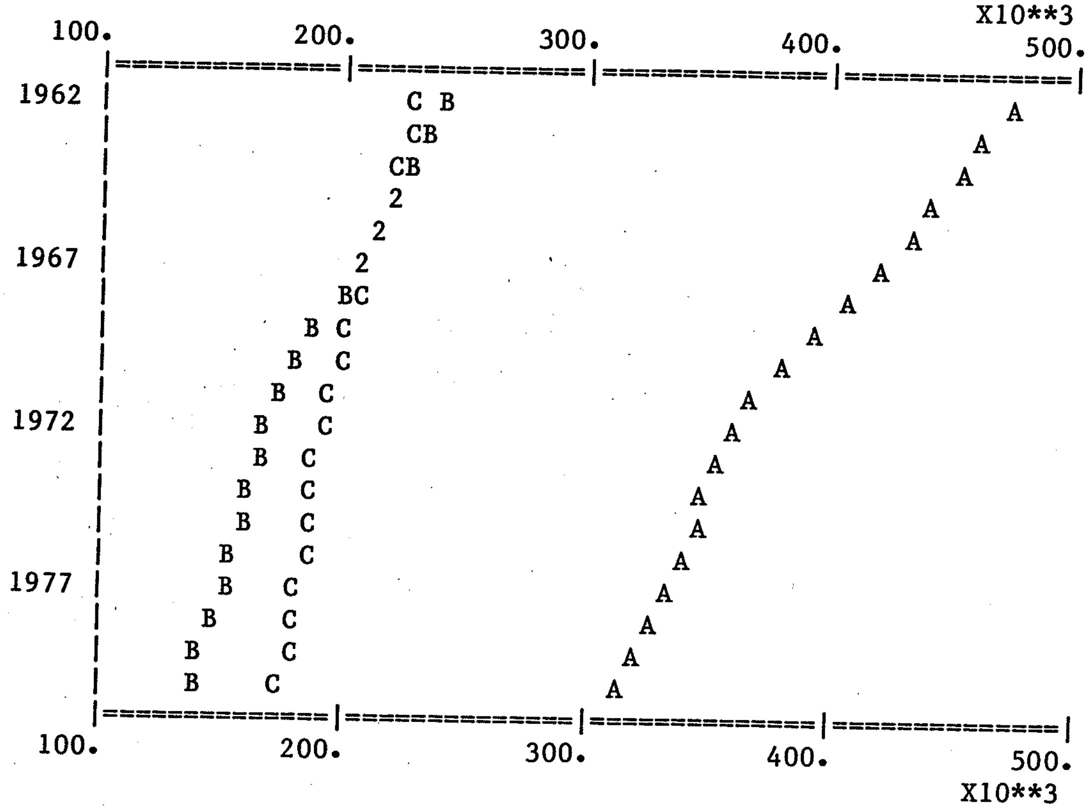
SYMBOL	SCALE	NAME
A	#1	AIMCAN
B	#1	AIMEST
C	#1	AIMWST

****

NOTA:
SYMBOLS A, B AND C REFLECT CANADA, EAST AND WEST RESPECTIVELY.
TROLL COMMAND: .

CHART 8:

NUMBERS OF FARMS BY REGIONS.




```
**************************LEGEND*****************************

TIME BOUNDS: 1962 TO 1980

SYMBOL  SCALE  NAME
   A      #1    FARMCAN
   B      #1    FARMEST
   C      #1    FARMWST

*************************************************************
```

NOTA:
SYMBOLS A, B AND C REFLECT CANADA, EAST AND WEST RESPECTIVELY.
TROLL COMMAND: .

CHART 9:

PRICE INDEX OF FARM MACHINERY BY REGIONS.
(1971 = 100.)

```
     70.     90.     110.    130.    150.    170.    190.    210.
     |=======|=======|=======|=======|=======|=======|=======|
1962 |B2
     | B2
     |  B2
     |   B2
     |    B 2
1967 |     B 2
     |      B 2
     |        B2
     |         B2
     |          B2
1972 |           B2
     |             B2
     |               B   2
     |                    B      2
     |                           B  CA
1977 |                               B   2
     |                                  B      2
     |                                        B     AC
     |                                              B     AC
     |=======|=======|=======|=======|=======|=======|=======|
     70.     90.     110.    130.    150.    170.    190.    210.
```

*************************LEGEND**************************

TIME BOUNDS: 1962 TO 1980

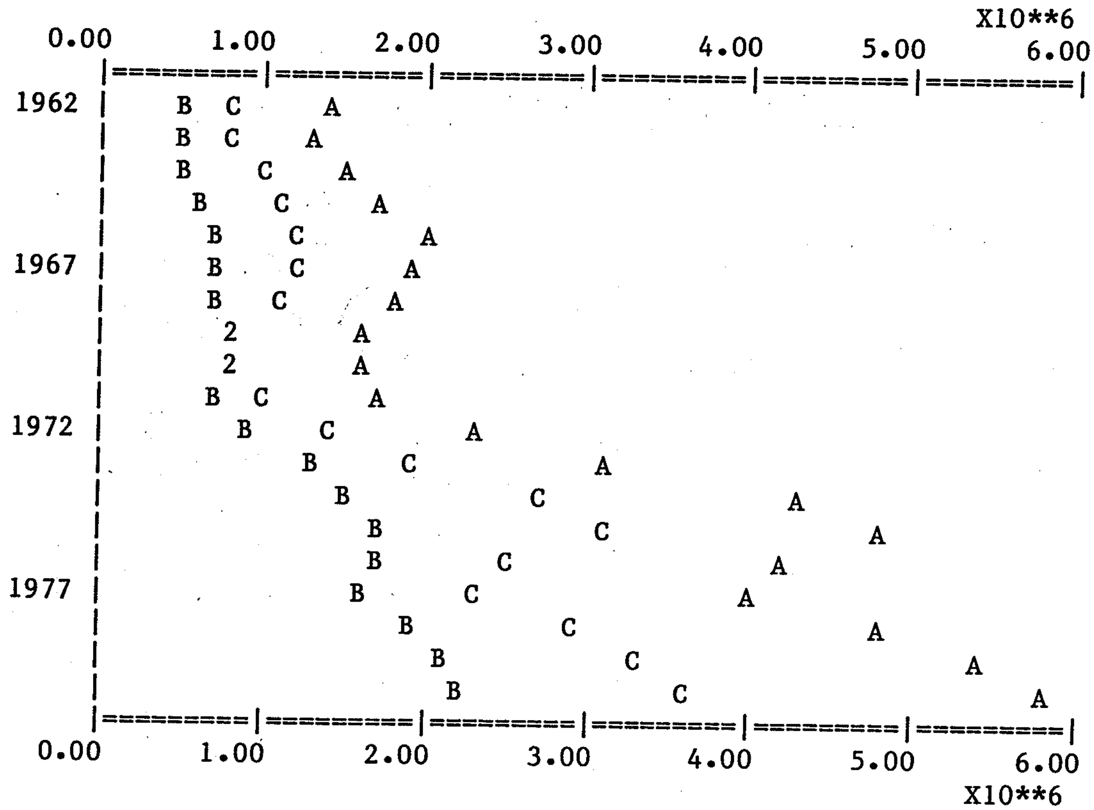
SYMBOL	SCALE	NAME
A	#1	PIMCHCAN
B	#1	PIMCHEST
C	#1	PIMCHWST

****

NOTA:
SYMBOLS A, B AND C REFLECT CANADA, EAST AND WEST RESPECTIVELY.
TROLL COMMAND: .

CHART 10:

CASH REVENUE BY REGIONS.
('000 OF NOMINAL DOLLARS)



**************************LEGEND****************************

TIME BOUNDS: 1962 TO 1980

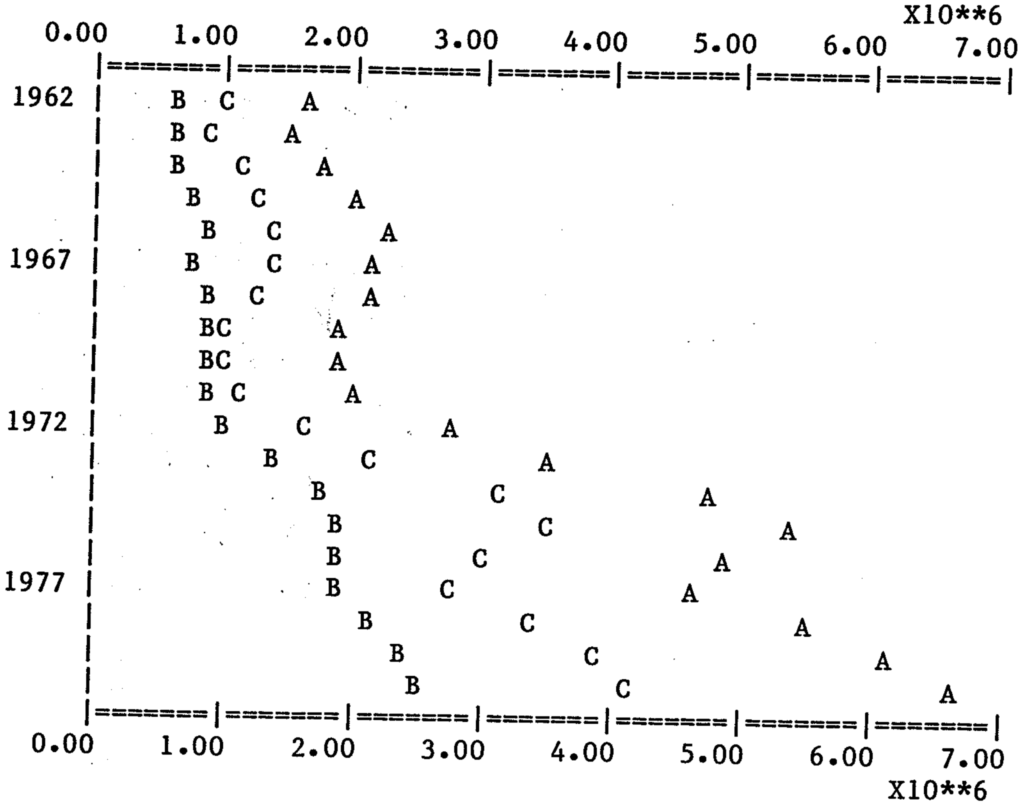
SYMBOL	SCALE	NAME
A	#1	CASHCAN
B	#1	CASHEST
C	#1	CASHWST

****

NOTA:
SYMBOLS A, B AND C REFLECT CANADA, EAST AND WEST RESPECTIVELY.
TROLL COMMAND: .

CHART 11:

REVENUE AVAILABLE FOR REPAIRS BY REGIONS.
('000 OF NOMINAL DOLLARS)



************************LEGEND**************************

TIME BOUNDS: 1962 TO 1980

SYMBOL	SCALE	NAME
A	#1	NREVCAN
B	#1	NREVEST
C	#1	NREVWST

****

NOTA:
SYMBOLS A, B AND C REFLECT CANADA, EAST AND WEST RESPECTIVELY.
TROLL COMMAND: .