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DISCUSSION PAPER NO. 352

Aggregate Provincial Agricultural Cost Functions for the Three Prairie Provinces

by

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RÉSUMÉ

Le présent document examine les coûts de la production agricole dans les trois provinces des Prairies au cours des années 1961 à 1985. Pendant cette période, les prix et les niveaux de production ont beaucoup varié. Le cours réel du blé a atteint un sommet au début des années 70, déclenchant un nouveau cycle de production, mais il a par la suite amorcé une glissade. L'inflation de la fin des années 70 et du début des années 80 s'est répercutée sur le prix de pratiquement tous les facteurs de production jusqu'à la récession de 1981. Le prix des terres a aussi été fortement touché.

Cette étude tient compte de tous les coûts économiques, de sorte qu'il a fallu imputer le coût du travail non rémunéré et les frais de financement des apports de capital et les ajouter aux coûts directement mesurables et comptabilisés. Le coût du facteur terre employé dans la production agricole a été évalué selon deux définitions différentes : 1) 4 % de la valeur de la terre et 2) le montant obtenu en multipliant le taux de location en vigueur par la superficie utilisée. Ces deux méthodes produisent des résultats assez semblables.

Un modèle de coût translog à rendements d'échelle constants a été estimé pour chacune des deux définitions du coût de la terre. L'élasticitié-prix de trois grandes catégories de facteurs -- travail, capital et autres facteurs -- révèle que le total des coûts de production est sensible à tous les facteurs, mais un peu plus aux apports de capital.

Le coût et le prix unitaires des produits a été calculé pour chaque année de la période étudiée. Si on comptabilise tous les coûts économiques, le prix unitaire n'a été supérieur au coût unitaire que pendant les quelques années où le cours réel du blé était à son sommet. Pendant les autres années, le coût était supérieur au prix. En d'autres mots, étant donné que le coût de tous les autres facteurs a été réellement payé, les rendements du travail non rémunéré et du capital ont été faibles pendant la plus grande partie de la période étudiée. Une deuxième série de coûts de production unitaires a été calculée sans prendre en considération les valeurs imputées du coût du travail non rémunéré et des frais de financement du capital, sauf pour le facteur terre. En 1985, le prix unitaire a été égal ou inférieur à ce coût unitaire et l'étau des coûts et des prix s'est resserré. Comme le fardeau de l'endettement et des paiements d'intérêts n'est pas réparti uniformément et peut être nettement supérieur à la moyenne dans de nombreux cas, notamment à cause du prix de la terre, la situation de beaucoup d'agriculteurs est certainement encore plus pécaire que ne l'indiquent les chiffres.

ABSTRACT

This paper examines the cost of production in agriculture in the three Prairie provinces for the period 1961 to 1985. This period covers a wide range of price and production levels, including a peak in real wheat prices in the early 1970s that triggered a new production cycle, and the start of the most recent downturn in real wheat prices. The inflation of the late 1970s and early 1980s affected virtually all input prices until the recession of 1981. Land prices were greatly affected.

Costs included all economic costs, requiring imputation to non-paid labour, land, and carrying costs of capital, in addition to the directly measured and reported costs. Two alternatives were used for the cost of land in production, a 4 per cent rate on the value of land, and the rental rate applied to the quantity of land. Both alternatives produced broadly similar results.

A constant return to scale translog cost model was estimated for each of the two land cost alternatives. The input price elasticities of the three broad aggregate inputs, labour, capital, and other inputs, indicated that total costs was sensitive to all inputs, but slightly more so to capital inputs.

Unit costs and price of output were calculated for each year in the sample period. On a full cost basis, unit price exceeded cost only for a couple of years during the peak in real wheat prices. For the remainder of the sample period cost exceeded price. Put another way, since all other costs were paid, the return to unpaid labour and to capital during most of the sample period was low. A second set of unit output costs were calculated which excluded imputed costs to labour, and capital carrying costs except for land. By 1985, unit price had dropped to this level of cost, or below, indicating the increasing severity of the cost-price squeeze. Given that actual debt loads and interest payments were not uniformly shared, and could in many cases be substantially higher, particularly for land, would indicate an even worse financial picture for many farmers.

CONTENTS

FOREWORD

This study forms part of a larger project examining the future in agriculture of the Prairie grain economy. It focuses on the evolution of the costs of agricultural production since 1961 in each of the three Prairie provinces.

Western farmers are being subjected to a serious cost-price squeeze. Rising costs during the inflation of the late 1970s followed by relative stickiness of cost combined with falling crop prices in the 1980s have produced this result. While much attention these days focuses on the worsening cash flow position and resulting increased risk of bankruptcy of individual farmers, this paper concentrates on the long-run costs in agriculture by imputing costs to all capital and labour employed in producing output. The analysis shows that only during 1973 and 1974, when real wheat prices were at a peak, did aggregate unit price exceed aggregate unit cost. This raises issues beyond the current debt crisis to adjustments in agriculture for long-term viability.

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Judith Maxwell
Chairman

AGGREGATE PROVINCIAL AGRICULTURAL COST FUNCTIONS FOR THE THREE PRAIRIE PROVINCES

INTRODUCTION

Agriculture is a major industry in Canada. Agriculture is an even more important sector in the Prairie provinces, and booms or busts in the western farm economy have a substantial impact on the overall Prairie economy. The current difficulties in major sectors of western agriculture have their roots in several factors, but the best point to begin an examination of western agriculture is perhaps in looking at the behaviour of grain prices.

Chart 1 presents the fluctuation in wheat prices, by province, over the period 1961 to 1986. Up until 1972, the price of wheat in nominal terms remained fairly constant. In 1973, the price of wheat rose dramatically, triggering a new production expansion cycle. After declining somewhat until 1976, the price again rose, to peak in 1980. The price declined modestly until 1984 before beginning a free-fall in 1985, up to the end of the data period and beyond. The period from the early 1970s to the early 1980s marked a strong upward trend in nominal wheat prices and more generally in overall grain prices.

In real terms, given the rate of inflation of the last half of the 1970s, wheat prices behaved quite differently. Overall, the period since 1973, which marked a peak in real wheat prices, has been marked by a downward trend in real prices offset only by a minor recovery centred in 1980. Currently, real wheat prices are at all-time lows. The movement of real wheat prices (in 1981 dollars) from 1961 to 1985 is graphed in Chart 2. Looked at in isolation, such real price movements seem highly erratic, the result of very unusual circumstances. Over a longer horizon, however, they fit the long-run downward trend of real wheat prices characterized by high price instability. Chart 3 depicts the real price movements of wheat over the period 1870 to 1980.

Of course, wheat is not the only output of western agriculture. There are a number of other major crops and livestock production as well. In order to get a broader measure of price movements, price indices were calculated for both livestock and crop aggregates, where the weight of any particular output in its aggregate was dependent upon the value share of that particular output. In Chart 4, the aggregate crop and livestock price indices are plotted from 1961 to 1985. The aggregate crop price index looks little different from wheat prices alone. Both crop and livestock prices moved up sharply during the 1970s; however, since the start of the 1980s, livestock prices have stayed relatively constant, while crop prices have dropped.

Production of crops and livestock in the Prairies over the same period is plotted in Chart 5. The expansion of crop production coincided with the price peak of the early 1970s, with the expansion in wheat production being a major contributor. Livestock production, on the other hand, increased much more slowly than crops and has been relatively flat from the early 1970s onward. These patterns are followed in each of the three Prairie provinces, with only minor variations from one province to another. More detail is given in the tables in Appendix B.

The increase in grain production in Canada during the late 1970s and early 1980s was not peculiar to Canada. The prices seen by Canadian farmers were a reflection of world prices. Output was expanded in major producing nations, and importing nations moved towards greater self-sufficiency. The result was a growing glut of surplus grain which currently depresses world grain prices.

Unfortunately, the rise in wheat prices of the 1970s were almost universally viewed as a move to long-run higher wheat prices. As such, much of the price rise in wheat was capitalized into land values. The price per acre of farm land over the period 1961 to 1986 is plotted in Chart 6. The rapid rise in land values during the 1970s reflects both the rise in wheat prices and the expectation that higher wheat prices were here to stay. While such a rise in land prices made it easier for older farmers to retire, it made entry by young farmers or expansion of existing operations much more expensive. Falling wheat prices in the 1980s resulted in falling land values, and in falling revenues to cover the cost of servicing debt burdens and, in fact, worsened after 1985, beyond the period presented in Chart 6. Those who had entered farming or who had expanded their operation were left with debts which, in many cases, exceeded asset values, and were thus left with little option except to produce more, provided variable costs were being covered, to try to counter falling prices. Older farmers relying on selling their farm to finance retirement were also faced with falling asset values which tended to reduce exit from farming by retirement.

The effect of rising land prices on capital employed in farming may be seen in Chart 7. By far the most striking feature of this chart is the rapid increase in the value of land and buildings up until the early 1980s, and then the decline with falling land prices. Machinery investment also increased as a result of both increased purchases and increased prices. In the case of land, there is little doubt that the inflation psychology prevalent during the last half of the 1970s contributed significantly to the price rise. Not only was the price of wheat rising (in both nominal and real terms), but land was viewed as a good hedge against inflation.

The start of the 1980s marked a turning point. Nominal interest rates were moving towards all-time highs, and real interest rates were increasing as inflation started to decline. The price of wheat (in both real and nominal terms) started to decline, resulting in lower returns to land in production. The psychology of the 1970s was reversed and land values tumbled, leaving in their wake higher debt and lower revenue to service the debt at high real rates.

This, however, is only one part of the overall cost picture. The high rates of inflation of the late 1970s and early 1980s also meant higher prices for most farm inputs. Chart 8 presents the total cash operating expenses for the Prairies from 1961 to 1986, a portion of which consists of interest payments on debt which is also shown separately in the chart. While total interest payments have increased, total operating expenses have increased more rapidly. Thus, the often referred to "debt crisis" in western agriculture is only part of the problem. Lower world prices for output, combined with higher operating costs, have put most farmers in a cost-price squeeze. Those with additional debt servicing costs due to increased debt loads and high interest rates are, of course, even more severely affected.

Government activity to help stabilize or supplement farm income through various programs has increased noticeably since 1984. In Chart 9, direct government payments as a part of realized gross farm income are plotted from 1971 to 1986. Increases in government payments have worked to stabilize gross farm income since 1984. Without government payments, gross farm income would have commenced a downward trend. As mentioned before, operating costs have increased substantially, reducing net farm income considerably. As may be seen in Chart 10, without government payments, net farm income would have dropped drastically and, in fact, the vast bulk of net farm income consists of direct government payments.

To summarize, western agriculture is being squeezed by declining revenue from farm operations and increasing input costs, leaving government payments as an increasingly important buffer against even more severe conditions. The purpose of this paper is to examine the input cost structure of the overall situation. To do so, we shall concentrate on total economic cost rather than simply looking at cash costs. In other words, we shall look at the longer-run situation in which it should be expected that all factors of production earn a return. This, of course, in no way diminishes the importance of cash costs to the survival of individual farm operations.

The analysis in this paper is carried out at the aggregate provincial level over the years 1961 to 1985. It was not feasible to extend the data base for analysis up to 1986 since the data required on outputs was not readily available. The analysis was carried out in the framework of an agricultural cost function relating total costs to the level of output and to input prices.

In Section 2, a translog cost model is introduced which will serve as a framework for the analysis in the subsequent sections.

Section 3 outlines the estimation of the cost model, while Section 4 describes the data and aggregation procedures. Results are presented and discussed in Section 5, and the paper concludes in Section 6.

Two appendices are attached. Appendix A describes a technical aspect associated with the estimation. Appendix B contains the detailed data and derived variables used in the analysis. Also included are supplementary calculations such as cost shares of different items and growth rates.

TRANSLOG COST MODEL

A cost function quantifies total costs of production of different levels of output for given input prices, when inputs are combined in a cost-minimizing fashion. That is, production follows a well-defined production process, with substitution allowed among inputs.

The starting point of any cost function is a cost equation

$$C = \sum_{i=1}^{n} P_i X_i$$

where C is the total cost of producing output Q

P_i is the price of input i, i=1, 2, ..., n

X_i is the quantity of input i used in producing Q.

That is, total cost is simply the sum of the price times quantity of all inputs. If a price were to change, however, the cost equation by itself could not tell us the new total cost because substitution would occur among inputs with changing relative prices.

The production technology, given by a production function,

$$Q = Q\ (X_1, X_2, \ldots, X_n)$$

when substituted into the cost equation, results in a cost function,

$$C = C\ (Q, P_1, P_2, \ldots, P_n)$$

relating total costs to output and input prices, given the production technology.

Generally speaking, the above procedure, when possible, is extremely messy, leading to the practice of starting with a cost function directly. Starting directly with a cost function, and by a series of plausible assumptions, duality theory implies that associated with the cost function is a production function whose input demand and technological relationships may be determined from the cost function alone, even though the dual production function may not be explicitly expressible in parametric form.

One type of cost function appearing more widely in published studies is the translog cost function. Among the advantages of using a translog function is that it is a valid second-order approximation to any arbitrary cost function, and it includes other forms of functions as special cases. The translog specification has been used in this study. Due to data limitations, the specific form used incorporates the assumption of constant returns to scale, which in agriculture appears reasonable. Thus, the translog cost function may be written

$$\ln C = \alpha_0 + \sum_{i=1}^{m} \beta_i \ln Q_i + \sum_{i=1}^{n} \alpha_i \ln P_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \alpha_{ij} \ln P_i \ln P_j$$

where there are m outputs and n inputs, and symmetry constraints and linear homogeneity in input prices along with constant returns imply the following parameter restrictions,

$$\sum_{i=1}^{m} \beta_i = 1 \; ; \; \sum_{i=1}^{n} \alpha_i = 1 \; ; \; \alpha_{ij} = \alpha_{ji} \; ; \; \sum_{i=1}^{n} \alpha_{ij} = \sum_{j=1}^{n} \alpha_{ij} = 0$$

With the assumption of cost minimization and perfect competition in input markets, sufficient conditions for Shephard's lemma are met, thus

$$\frac{\partial C}{\partial P_i} = X_i \qquad i = 1, 2, \ldots, n$$

where X_i is the cost-minimizing quantity of input i. And, therefore,

$$\frac{\partial \ln C}{\partial \ln P_i} = \frac{\partial C}{\partial P_i} \frac{P_i}{C} = \frac{X_i P_i}{C} = S_i$$

where S_i is the cost share of input i in total costs of production.

Partial differentiation of the translog cost function with respect to input prices results in a set of cost share equations

$$S_i = \alpha_i + \sum_{j=1}^{n} \alpha_{ij} \ln P_j , \quad i = 1, 2, \ldots, n.$$

The complete set of n equations is singular, but symmetry and linear homogeneity allow reducing that set to n-1 equations

$$S_i = \alpha_i + \sum_{j=1}^{i} \alpha_{ij} \ln \frac{P_j}{P_n} + \sum_{j=i+1}^{n-1} \alpha_{ji} \ln \frac{P_j}{P_n} \quad , \; i = 1, 2 \ldots, n-1$$

with the parameters of the n^{th} equation being determined residually.

The cost function along with the n-1 share equations form a system of n equations to be estimated. The derivation of substitution elasticities and factor demand elasticities may be found elsewhere.[1] The elasticity of costs with respect to input prices, which are of primary concern in this paper, are given directly by the parameters.

ESTIMATION

For purposes of estimation, several additional features need examination. First, a level of aggregation for outputs and for input prices must be established, and second, some account must be taken of technological progress.

The length of the data time series, covering the years 1961-85, dictates a high level of aggregation. In this study, we have aggregated to two outputs, crops and livestock, and three inputs, labour, capital, and other inputs. The cost of land is included in capital.

Provision for technical change has been incorporated in as simple a way as possible, by including a time trend. This, again, is a concession to the shortness of the time-series. Thus, the estimated equation takes the form

$$\ln C_t = \alpha_c + \alpha_1 \ln t + \beta_1 \ln Q_{ct} + \beta_2 \ln Q_{1t} + \gamma_1 \ln P_{1t}$$

$$+ \gamma_2 \ln P_{kt} + \gamma_3 \ln P_{ot} + \gamma_{11} \frac{1}{2} (\ln P_{1t})^2 + \gamma_{12}$$

$$\ln P_{1t} \ln P_{kt} + \gamma_{13} \ln P_{1t} \ln P_{ot} + \gamma_{22} \frac{1}{2} (\ln P_{kt})^2$$

$$+ \gamma_{23} \ln P_{kt} \ln P_{ot} + \gamma_{33} \frac{1}{2} (\ln P_{ot})^2 + U_{1t},$$

while the two share equations, for labour and capital, take the form

$$S_{1t} = \gamma_1 + \gamma_{11} \ln \frac{P_{1t}}{P_{ot}} + \gamma_{12} \ln \frac{P_{kt}}{P_{ot}} + U_{2t}$$

$$S_{kt} = \gamma_2 + \gamma_{12} \ln \frac{P_{1t}}{P_{ot}} + \gamma_{22} \ln \frac{P_{kt}}{P_{ot}} + U_{3t}.$$

The symmetry conditions have been incorporated in the formulation, while the restrictions for constant returns to scale and linear homogeneity in input prices are given by

$$\beta_1 + \beta_2 = 1, \quad \gamma_1 + \gamma_2 + \gamma_3 = 1, \quad \gamma_{11} + \gamma_{12} + \gamma_{13} = 0,$$

$$\gamma_{12} + \gamma_{22} + \gamma_{23} = 0, \text{ and } \gamma_{13} + \gamma_{23} + \gamma_{33} = 0.$$

Assuming that the error terms are serially uncorrelated, but that the error terms in different equations are contemporaneously correlated, the system is estimated by joint generalized least squares (JGLS), where the same parameter in different equations is constrained to take the same value.

Furthermore, since agriculture in all three Prairie provinces is often affected by the same factors, the total set of nine equations, three for each province, are simultaneously estimated by JGLS.

Finally, since the rise to which these cost functions are put is to develop incremental costs of crop and livestock output, we have the problem of biased predictions of total cost. This problem is considered in detail in Appendix A. In the analysis in this paper, the bias was extremely small, and for all practical purposes could be ignored.

DATA

Data were collected at the detailed level and then aggregated to variables used in the estimating equations for each province. Table 1 lists the items for which data on production, marketings, expenditures, prices, and quantities, as required, were collected.

In Appendix B the actual data are presented in tabular form. In addition the calculated aggregates are also presented. Sources of data are indicated there, while adjustments to the data and methods used to derive the aggregates are presented in this section.

Before getting into the adjustments it must be understood that what we are attempting to obtain are unduplicated data at the provincial level.[2] That is, we are treating each province as a comprehensive unit and are trying, as far as possible, to avoid double-counting. Thus, for example, feed grain grown in the province and sold to a livestock producer in the same province is considered an intermediate good, and is neither an output nor an input. Only transactions into or out of agriculture within a province, or transactions into or out of a province, are considered as inputs or outputs. In some instances, such as grain sold to a commercial seed processor and subsequently resold to a farmer, it has not been possible to avoid double-counting, and hence would appear both as an output (grain marketings) and as an input (seed purchases). In such cases, it would have been preferable to have included only the value-added outside the agriculture sector as an input.

What this emphasis on avoiding double-counting means is that we are restricted to data which have been adjusted to this basis. For example, crop marketings have been adjusted to avoid double-counting; however, production data have not. The restriction is not severe since most data have been adjusted to provide unduplicated provincial agricultural statistics. However, the procedure can lead to some seemingly strange results. For example, in certain years the provincial output of oats in Alberta is negative. This arises because inventory reductions exceed marketings. A large proportion of the inventory reduction is for within-province livestock feed and thus is not included in provincial marketings. In such cases, in order to avoid negative output shares, the procedure followed was to shift the negative output to an input. The effect of this was to shift labour, capital, and other inputs of previous years, embedded in inventory, to current input.

Livestock purchases from outside the province were not included in current input cost but they were included in livestock inventories where they incurred carrying costs. Livestock output consisting of marketings plus inventory change was reduced by the purchases. For purchased livestock, inputs consisted of labour, capital and other inputs added within the sector, while output consisted only of value added and not gross output.

The first major adjustment made to the output data consisted of modifying the output to take account of weather variations for the six major crops; wheat, oats, barley, rye, canola, and flax seed. To do this, production of each crop was adjusted by weather factors found in Wisner (ECC, forthcoming). These factors are plotted in Chart 11, while the numbers are contained in a table in Appendix B.[3] The production adjustment was then added to or subtracted from output to obtain the output that would have resulted with normal weather.

The aggregation of output into crops and livestock was then accomplished in a straightforward fashion by converting all outputs to constant 1981 prices and simply adding constant dollar values.

The input factors present a more complex problem. In the first place, what we are interested in is the notion of economic cost, not cash cost. As a result, some costs must be imputed, both in labour inputs and capital inputs. Generally speaking, all other inputs are measured in terms of cash expenditures within a year.

Labour costs must be imputed because only a fraction of the agricultural labour force is paid. Owner-operators and family members are unpaid, but should not be considered a free resource. For most of the sample period data exist on employment in agriculture by type of worker, but not the amount of work. For hired labour, data on total yearly payments exist and were used in conjunction with employment data to derive an effective annual wage which was considerably below the reported annual nominal price of hired labour. The effective annual wage for hired workers was used to impute labour costs to unpaid family members. Owner-operators were imputed a wage based upon the provincial average industrial composite wage.

The effect of these imputations on total labour costs is substantial. Roughly 90 to 95 per cent of total labour costs are imputed with owner-operators accounting for 80 to 85 per cent of the total. Labour costs as a proportion of total costs decline from about 50 per cent in 1961 to just over 20 per cent in 1981 before rising to nearly 30 per cent in 1985. These figures may be seen in the tables in Appendix B.[4]

The imputations in the case of capital inputs are required to obtain annual costs of stock inputs which are used over long periods and contribute only a portion of their value to any year's output. There are two costs to be considered, the annual cost of holding the stock, and the cost of that portion of the stock used up during the year. In this study, all capital stocks, excepting land, were carried at the prime rate. Annual use through depreciation is reported directly in the data.

The treatment of land is somewhat different. With rising land prices, the return to land in agriculture includes both a return to agricultural production and a speculative return from rising land values. The only cost that should be included is that associated with agricultural production, and not that associated with land speculation. The costs associated with agricultural production have been measured in two ways. One set of costs were calculated using a long-run real interest rate of 4 per cent,[5] while a second set of costs were calculated using the reported rental rate for farmland. The results for these two calculations produced results for total costs that were quite similar as may be seen in Chart 12 to Chart 14. For comparison purposes other interest rates were used in calculating land costs. As may be seen in the same charts, the cost of land and total costs were sharply higher in the late 1970s and early 1980s when these rates were at high levels. Also, for comparison purposes, cash costs excluding all imputations and depreciation, but including reported interest payments on debt, are presented in the same charts. The calculated values in all cases are presented in tables in Appendix B.[6] For purposes of estimation of cost functions we have considered only two sets of total costs, those associated with a 4 per cent real rate for land, and those calculated using the farmland rental rate.

The cost function, as presented in the second section of this paper requires input prices. For this purpose, we have constructed Tornqvist price indices for each aggregate input.

The Tornqvist price index is calculated in the following manner. Suppose we have T observations on n inputs, $X_{i,t}$, i=1, 2, ..., n; t=1, 2, ..., T, with associated prices, $P_{i,t}$, which we wish to aggregate into one composite price index. The total expenditure on the n inputs in each year is given by,

$$C_t = \sum_{i=1}^{n} P_{i,t} X_{i,t}, \quad t = 1, 2, \ldots, T.$$

The expenditure share of the i^{th} input in the total expenditure on all n inputs is,

$$S_{i,t} = \frac{P_{i,t} X_{i,t}}{C_t}, \quad i = 1, 2, \ldots, n; \; t = 1, 2, \ldots, T.$$

The Tornqvist price index is calculated recursively by

$$P_t = \left[\prod_{i=1}^{n} \left(\frac{P_{i,t}}{P_{i,t-1}} \right)^{\frac{1}{2}(S_{i,t} + S_{i,t-1})} \right] P_{t-1}, \quad t = 2, 3, \ldots, T.$$

The calculated price index is then normalized about its mean, and thus the starting value of the index may be arbitrarily chosen. One such price index is calculated for each of labour, capital and other inputs. These price indices are presented in the Data Appendix.[7]

RESULTS

The system of cost functions and cost share equations for all three provinces was estimated by joint generalized least squares as described earlier. Two sets of estimations were done, one where the cost of land was calculated at a 4 per cent interest rate of its value, and the other where the cost of land was calculated at the rental rate for land. The results of the estimations are contained in Table 2A and Table 2B, respectively. Only the results for the parameters of the cost functions are presented, since all the parameters appearing in cost share equations also appear in the cost function, and are constrained to be equal in the estimation.

With respect to the parameter estimates, there is little to choose between the two specifications of land cost. The parameter estimates associated with the output variables and with the input price variables are very similar in both specifications. The parameters of the interaction terms do vary somewhat from one specification to the other. Overall, the regression using a 4 per cent real cost for land appears the stronger of the two specifications.

The parameters associated with the output variables are the elasticity of total costs with respect to output, either crops or livestock. They represent the percentage increase in total costs for a 1 per cent increase in output. The sum of the livestock and crop parameters has been constrained to equal unity, in line with the assumption of there being no economies or diseconomies of scale. Tests of the constraint showed that it was weakly binding at the 5 per cent level of significance in all three provinces, and that mildly decreasing returns to scale were indicated.

The output elasticities vary from one province to the next depending upon the relative importance of the two aggregate outputs in total provincial output. Thus, the coefficient on livestock output is highest for Alberta, where the relative importance of livestock production is the greatest, and lowest for Saskatchewan where the importance of livestock production is least. Manitoba falls between the two. Livestock contributes more to cost, per unit of output, than do crops.

The marginal unit costs of output are relatively straightforward to calculate from the estimated equations. It is here that the problem of bias, outlined in Appendix A, becomes a consideration. In this particular case, however, it is not a significant consideration. The procedure consisted of incrementing output by a constant dollar amount and recalculating total costs. The incremental total cost was then divided by the weighted average constant dollar price of all items in the aggregate output measure to obtain a cost per physical unit of output. A corresponding market price was also calculated. The results of these calculations are presented in Chart 15 to Chart 17 and in Table 3 to Table 5. In those charts, the unit total costs for both land cost alternatives are plotted as cost4 and costr corresponding to the 4 per cent real rate and the rental cost of land respectively. Also plotted are two intermediate cost curves, costi4 and costir. The costs of the latter excluded all imputed labour income, leaving only paid labour as an input in that category, and excluded carrying costs for machinery, equipment, and inventories. Depreciation on machinery and equipment was included as were carrying costs for land using both alternatives.

Both sets of cost calculations follow much the same pattern with the intermediate costs generally being below the price line and the full costs generally above. Where the two sets tend to diverge, from about the mid-1970s onward, it is due in large part to carrying costs at high interest rates being omitted from the intermediate costs. The picture that emerges from these cost curves is that fully allocated costs are not often covered. Put another way, the return to unpaid labour or to capital, once other costs have been paid, is low. The sharp price drop, starting in 1984, with only moderately declining costs is resulting in an ever-tightening cost-price squeeze leading to a worsening net income position as was evidenced in Chart 10.

While it would have been technically possible to examine the cost-price squeeze separately for crop and livestock production using the analysis of this paper, it would probably be misleading to do so. One of the main reasons has to do with the treatment of the cost of land. Generally speaking the land used in livestock production is of lower quality than that used in crop production. In the aggregate time-series data we have no quality data for land with which we could make adjustments. Thus, it is quite possible that separate cost curves could mis-state unit costs for crops and livestock when an average quality is used for both. This speculation is reinforced when one looks at the divergence of the cost lines for 4 per cent and the rental rate in Alberta which has the highest concentration of livestock production of the three provinces. If most of the land rental is for livestock production, then the rental rate used in the cost calculations would be too low.

No matter what refinement one would like to make to the cost curves, the overall result is clear. A significant factor in the cost-price squeeze is due to the rising cost of production from the mid-1970s onward, corresponding to escalating inflation. It is this phenomenon which we shall now analyze.

The parameters associated with the input price variables give the elasticity of total costs with respect to input prices. They are the percentage increase in total costs for a 1 per cent increase in input price. The sum of input price parameters across the three inputs, labour, capital, and other inputs, has been constrained to equal unity. This is the usual constraint of linear homogeneity in input prices, such that if all prices were to change by a fixed proportion, total costs would also change by that same proportion. Tests of these constraints at the 5 per cent level of significance showed that the constraint of linear homogeneity in input prices was non-binding in all three provinces.

The input price elasticities are all between 0.24 and 0.42, indicating the importance of all three aggregate inputs in total cost of production. The input price elasticity of capital is always the greatest. This would not hold when only cash costs were considered, since both labour and capital contain large imputed elements, while other costs are all cash costs. Even though the elasticities for total cost are all roughly of the same magnitude, this does not necessarily mean that the rise in the unit cost curve is due to all inputs. For this we have to turn to actual price changes of the inputs and their cost shares. Tables in Appendix B[8] contain all this information.

Over the years 1961 to 1985, cost shares of the major input aggregates have changed substantially. Labour costs, paid and imputed, have declined from over half of total costs in 1961 to under one-quarter in 1981 before increasing to nearly 30 per cent in 1985. Capital costs, on the other hand, have increased from roughly one-quarter of total costs in 1961 to roughly one-half in 1981 before starting a decline to 1985. Other costs have increased, more or less steadily, as a proportion of total costs in all three provinces throughout the entire period.

Even a declining cost share, however, can be associated with an increasing cost -- it is just that the cost of other inputs is rising more rapidly. This, in fact, is just what has happened in all three provinces. While capital and other costs have risen by 9 to 11 per cent at an average annual compound rate from 1961 to 1985, labour costs have risen by only 5 to 6 per cent. Total costs have increased by about 8 to 8.5 per cent. In all three provinces, capital and other costs started a rapid increase in the early 1970s ending in about 1981, when capital costs started to decline while the increase in other costs moderated. Labour costs started to rise quite steeply in about the mid-1970s, but were more erratic than the other two cost aggregates. As a result, total costs showed very strong growth from 1973 to 1981. This, of course, is entirely expected since 1973 to 1981 marked both a period of expanding production and a period of accelerating inflation so that both quantities and prices of inputs were increasing.

Growth rates in aggregate prices for labour input were 7 to 8 per cent at a compound annual rate from 1961 to 1985. Thus, prices increased more rapidly than total labour cost indicating a decline in the quantity of labour. However, since about 1982, growth in labour prices has generally been lower than increases in total labour costs, indicating a slight reversal in the trend to declining agricultural employment. At the sub-aggregate level, the largest component of labour cost was that imputed to owner-operators which comprised roughly 85 per cent of total labour cost. From 1961 to 1985 labour costs imputed to owner-oprators grew at an average compound annual rate of 5 to 6 per cent, while the growth in average imputed wages was of the order of 7 to 8 per cent indicating the declining number of owner-operators. The period of highest growth in imputed wage levels occurred from 1974 to 1982.

The only cash expense in labour costs is that associated with paid labour. The share of paid labour in total labour costs has increased by about 4 percentage points from 1961 to 1985, ranging from 10 to 13 per cent of total labour costs in 1985. Paid labour costs increased at a compound annual rate of 7 to 8 per cent, while the effective wage for paid labour increased by 6.5 per cent in Manitoba, 9.6 per cent in Saskatchewan and 8.1 per cent in Alberta. Unpaid family workers are the smallest group by cost share which declined over the sample period.

The growth rate of prices for aggregate capital inputs on a compound annual basis ranged from 6.5 to 7.5 per cent, with Manitoba having the lowest and Alberta the highest rate. In all provinces the growth rate of capital prices was lower than the growth rate of capital costs as western agriculture became more capital intensive.

There are three main components in capital costs, machinery depreciation, carrying costs for land, and carrying costs for machinery and equipment. Land is carried at a 4 per cent rate while other stocks are carried at the prime rate. The major run-up in both costs and prices of these components occurred in the 1973 to 1984 period. For machinery and equipment depreciation and carrying costs, the growth in costs exceeded the growth in prices as more machinery and equipment was purchased and used in production. For land, however, the growth rates in total costs and prices moved in lockstep over the period 1972 to 1981, so that virtually all of the cost increase in land was due to the increased value of land and none to the increased use of land in production. Since 1982, both costs and value of land declined in tandem, so that once again the amount of land in production remained about constant.

In the "other" inputs category, prices increased at just over one-half the rate of increase of total "other" costs at an annual compound rate between 1961 and 1985, indicating the increase in quantity of "other" inputs. Once again, the major increases in both costs and prices occurred between the early 1970s and 1981. The major components in this aggregate consist of fuel for machinery, machinery repairs, fertilizer, pesticides, and livestock feed. Together they accounted for roughly two-thirds of "other" input costs in 1961 rising to about three-quarters of "other" input costs in 1985. The shifts in cost shares of individual components has been striking. The cost shares of machinery fuel and of machinery repairs has declined by about 10 percentage points from 1961 to 1985. The cost share of fertilizer has risen by 15 or more percentage points and pesticides by somewhat less. The cost share of livestock feed in Manitoba and Alberta is an important input, fluctuating between 10 and 20 per cent of "other" costs over the years.

All "other" inputs have increased in quantity and price over the sample period. The most important cost increases have occurred in fertilizers and pesticides, with compound annual growth rates ranging from 15 to 20 per cent, and price increases in the 5.5 to 6.5 per cent range. The most rapid price increases for fuel, machinery maintenance, fertilizers and pesticides occurred after the 1973 and 1979 oil price shocks.

In summary, what has happened is that after a high real price for wheat in 1972, a new increasing production cycle started. Most inputs, with the notable exception of land, increased resulting in increased input costs. At the same time, all input prices rose, especially land, causing total input costs to rise even more quickly. Given input price elasticities of about the same magnitude among the aggregate inputs, the rise in unit costs was broad based, although the cost of land still remains a major culprit.

Finally, technical change included as a time trend in the regression, while significant, is small. It has kept the growth rate in unit costs below the growth rate of input prices, however, the behaviour of unit costs is still largely the result of input prices. In order to predict the behaviour of unit costs one would need to develop methods to predict the trends of input prices, which is beyond the scope of this paper. The effect of technical change in such projections would be minuscule.

CONCLUSION

The purpose of this paper has been to analyse the long-run costs of agriculture in the Prairie provinces over the period 1961 to 1985. Costs were imputed to owner-operators, unpaid family workers, and to capital carrying costs. Stocks of machinery and equipment and inventories of livestock and crops were carried at the prime rate, while two alternatives were used for land, a 4 per cent real rate and an average provincial rental rate.

The results show that in only two years, 1973 and 1974, were total costs covered at the peak in real wheat prices, and then only for Saskatchewan and Manitoba with a relatively high proportion of wheat production to total production. By removing the imputed cost of labour and the capital carrying cost for machinery and equipment and inventories, leaving the cash cost and the cost of land, the picture changes to one of positive returns up to the most recent years. From 1985, however, plummeting prices and more slowly declining costs of output produced a cost-price squeeze that, were it not for government support, would make the saying "living off the land" literally true. Many farmers with interest payments on debt would be in greater financial difficulty.

In this paper we have not examined the revenue side in any detail, except to note that in recent years virtually all net income in western agriculture is from government support. The implication of this is that even with increases in the market price of output, initially the reduction of government support would leave net income little changed.

On the cost side, increases up to 1981 have been widespread. Costs increased because of the increase in land values, triggered by high wheat prices in the early 1970s, because of high capital carrying costs, due to high interest rates, and because of price increases in virtually all inputs. Since 1981 the price of land has declined quite sharply, interest rates have moved well below their peak although in real terms they remain quite high, but the price of other inputs remains quite sticky. The result has been total costs declining at a slower rate than revenue. When the market price of output starts increasing again, and it will, the costs, initially at least, should be relatively sticky towards increases given the current overall economic climate. In the longer run there is the question as to how much of the price increase will again be capitalized into land values.

There are two fundamental dimensions of wheat prices that have contributed to the crisis in western agriculture. The first is the level of prices, and the second is the instability. In Chart 3 it was seen that wheat prices over the long run have been on a downward trend. The long-run adjustment to this trend has been an out-migration of farmers from agriculture. Remaining farmers, in order to maintain income levels and standards of living, have increased farm size, such that there has been very little change in total farm land acreage. Yield technology domestically and worldwide, combined with better management techniques has, in conjunction with production-related subsidies, virtually ensured a continuation of the downward pressure on price levels.

Increasing farm size and increasing mechanization is a mixed blessing. Even though there is no evidence of increasing returns to scale, a larger operation will mean an improved net return to the owner-operator provided the price is high enough. There are limits, however, as to how much one operator can handle. Along with larger farm size come higher debt loads and greater financial risk from price fluctuations. The intergenerational transfer of farms is also made more difficult.

In addition to the income motivation for increasing farm size, governments as a matter of policy have looked favourably on family-operated farm operations. Thus one can find favoured treatment of on-going farming operations and the transfer of farm assets to succeeding generations. In particular, tax treatment has become more important as farm size increased. While such policies do address the primary concern, there are side effects. During a run-up in grain prices, the returns to land in agriculture are almost secondary to the return on land in the form of tax-favoured capital gains. Fluctuation in product prices can be magnified in land value fluctuations. Increasing farm size on a price upswing holds out the possibility of enhanced returns, but because of price instability in product markets, it is a risky strategy.

The solutions to the crisis in western agriculture are not clear-cut. Initiatives to address the immediate problems could well have long-run adverse consequences, while looking only at the longer run could leave unacceptably high levels of distress today.

In the longer run, international action on reducing product-related subsidies to lower production and allow market prices to rise is certainly indicated. In the complete absence of subsidies the cost structure presented in this paper certainly indicates an incentive for out-migration. To the extent that subsidies are used to control and smooth adjustment, they could be directed towards income subsidies rather than product subsidies.

However, even if the level of prices were to increase because of coordinated international policies, price instability would remain because of the dependence of agriculture on uncontrollable factors. At higher levels, price instability can still cause speculative booms and busts similar to the recent one and similar to the ones that occur in residential housing. Part of the solution towards damping such cycles is to introduce greater neutrality into investment choices. Another part of the solution is to allow greater scope for averaging through the use of registered loans and registered savings. The use of such instruments has been described elsewhere[9] and will not be repeated here.

Taken together, such measures would allow farmers to earn a better living and provide greater stability through an enhanced scope for both product and financial diversification and a higher level of prices for their output. In the short run, it would do little for farmers facing a debt crisis. Certainly there is no immediate need to pursue neutrality in investment decisions, but there is a need to address the financial distress that would remain. A balance between short and long term has to be struck.

NOTES

1 See for example: Grant, James Howard, "Substitution Among Labour, Labour and Capital in United States Manufacturing," Chapter 1, unpublished Ph.D. Thesis, Department of Economics, Michigan State University, 1979; or Allen, R.D.G., Mathematical Analysis for Economists, Chapter XIX, Macmillan, 1938.

2 The data published by Statistics Canada on most of the aggregate provincial series are adjusted to avoid double counting.

3 Tables AO-2, SO-2, MO-2.

4 Tables AI-4.1, AI-4.2, SI-4.1, SI-4.2, MI-4.1, MI-4.2.

5 A real interest rate of 4 per cent was also used by Brinkman and Prentice (1983).

6 Tables AI-2.1, AI-2.2, AI-2.3, SI-2.1, SI-2.2, SI-2.3, MI-2.1, MI-2.2, MI-2.3

7 Tables AI-3, SI-3, MI-3.

8 Tables AI-1.1, AI-1.2, AI-1.3, AI-4.1, AI-4.2, AI-4.3, AI-4.4, AI-5.2.2, AI-5.3.2, AI-5.4.2, SI-1.1, SI-1.2, SI-1.3, SI-4.1, SI-4.2, SI-4.3, SI-4.4, SI-5.2.2, SI-5.3.2, SI-5.4.2, MI-1.1, MI-1.2, MI-1.3, MI-4.1, MI-4.2, MI-4.3, MI-4.4, MI-5.2.2, MI-5.3.2, MI-5.4.2.

9 See, for example, Road Map for Tax Reform, a Statement by the Economic Council of Canada, Ottawa, 1987, or The Taxation of Savings and Investment, a research report prepared for the Economic Council of Canada, Ottawa, 1987.

Table 1

Items on Which Data are Available by Prairie Province and Variables Collected

Farm outputs	Variables
Field crops	
Wheat	Production (bushels)
Oats	Average farm price
Barley	Marketings
Rye	Inventory change
Mixed grains	
Corn for grain (Manitoba and Alberta only)	
Buckwheat (Manitoba only)	
Flaxseed	
Canola seed	
Potatoes	
Tame hay	
Fodder corn (Manitoba and Alberta)	
Lentils	
Vegetables	
Asparagus (Manitoba)	Marketings (tons, lbs, ...)
Beets (Manitoba)	Price
Cabbage (Manitoba and Alberta)	
Carrots (Manitoba and Alberta)	
Cauliflower (Manitoba)	
Celery (Manitoba)	
Cucumbers (Manitoba and Alberta)	
Onions (Manitoba and Alberta)	
Parsnips (Manitoba)	
Tomatoes	
Rutabagas (Manitoba and Alberta)	
Potatoes	
Sugar beets (Manitoba and Alberta)	
Mustard seeds	
Sunflower seeds	
Dry peas	

Table 1 (cont'd)

Farm outputs	Variables
Livestock and products	
Cattle Calves	Marketings (cwt) Price ($'s per cwt) Home consumption + inventory change (head) Price ($'s per head) Imports (head) (available from 1971 only) Price for imports (available from 1971 only)
Hogs Sheep Lambs	Marketings (cwt) Price ($'s per cwt) Home consumption + inventory change (head)
Fowl and chickens Turkeys	Price ($'s per head)
Fluid milk Eggs Wool Honey	Marketings Home consumption Price
Industrial milk Furs	Marketings Price
Inputs and expenses	
Real estate inputs	
Annual service cost of land use	Current market value of land and buildings Imputed current farm house value Average land and buildings price per acre Farm Credit Corporation mortgage interest rate
Building depreciation	Depreciation on buildings (current $'s) Building replacement price index
Building repairs	Expenditures on building repairs (current $'s) Building repairs price index

Table 1 (cont'd)

Inputs and expenses	Variables
Fencing	Fencing expenditures (current $'s) Fencing construction price index
Property taxes	Property tax expenditures (current $'s) Property tax rate index
Property insurance	Property insurance payments - indemnity payments (available from 1971. Prior to 1971 only aggregate insurance) Homeowners' insurance premiums component of CPI for Canada
Gross farm rent	Gross farm rent (current $'s) Farm rent price index (West Canada index)
Labour inputs	
Farm operators	Employment (number of persons) Average weekly earnings of provincial industrial composite
Unpaid family workers	Employment (number of persons) 90 per cent of monthly wage to paid workers
Paid workers	Employment (number of persons) Average monthly cash wage
Farm machinery inputs	
Annual service cost of machinery inventory capital investment	Current value of machinery and equipment Machinery replacement price index Interest rate
Machinery depreciation	Depreciation on machinery (current $'s) Machinery replacement price index

Table 1 (cont'd)

Inputs and expenses	Variables
Machinery repairs	Expenditures on machinery repairs (current $'s) Machinery maintenance price index
Livestock inputs	
Annual service cost of livestock inventory capital investment	Current value of livestock and poultry Feeder livestock price index Interest rate
Livestock services expense	Expenditures on artificial insemination, veterinary services, breed association fees Artificial insemination price index (Western Canada index)
Annual service cost of farm-held inventory of hay and fodder corn	Tame hay) Production Fodder corn) Average farm price Interest rate (Both tame hay and fodder corn are assumed to be stored on farms and fed to livestock within the province of production and within the first nine months of the crop year)
Annual service cost of farm-held inventory of major feed grains	Feed wheat)"Feed, waste and Oats)dockage" less Barley)dockage Rye) Mixed grain)Average farm Corn for grain)price Interest rate
Feed purchases	Expenditures on feed (current $'s) Feed input price index (Western Canada)
Crop inputs	
Annual service cost of seed inventory	Data not available
Seed purchases	Expenditures on seed (current $'s) Seed input price index

Table 1 (cont'd)

Inputs and expenses	Variables
Fertilizer	Expenditures on fertilizer (current $'s) Fertilizer input price index (West)
Pesticides	Expenditures on pesticides (current $'s) Agricultural chemicals input price index (West)
Twine, wire and containers	Expenditures on twine, wire and containers (current $'s) Small tools input price index
Irrigation	Expenditures on irrigation (current $'s) Property tax rate
Crop insurance	Crop insurance payments - indemnity payments (available only from 1971. Prior to 1971 only have aggregate insurance) Average premium per acre
Energy inputs	
Petroleum, diesel oil and lubricants for machinery	Expenditures on petroleum, diesel oil and lubricants for machinery (current $'s) Petroleum products input price index
Heating fuel	Expenditures on heating fuel (current $'s) (available back to 1971) Petroleum products input price index
Electricity	Expenditures on electricity (current $'s) Electricity and telephone price index (1961-71) Electricity price index (1971-85)
Telephone	Expenditures on telephone (current $'s) Electricity and telephone price index (1961-71) Telephone price index (1971-85)

Table 1 (cont'd)

Inputs and expenses	Variables
Miscellaneous inputs	
Custom work	Expenditures on custom work (current $'s) Custom work input price index
Other miscellaneous	Expenditures on other miscellaneous items (current $'s) Supplies and services input price index (Western Canada index)
Interest on indebtedness	Payments of interest on indebtedness (current $'s) Interest rate

Table 2-A

Cost Function Estimates Joint Generalized Least Squares - All Provinces 4 Per Cent Interest Rate on Land

	Alberta		Saskatchewan		Manitoba	
Variable	Parameter	T-statistic	Parameter	T-statistic	Parameter	T-statistic
Intercept	0.76652	42.577	0.85883	18.596	0.78002	29.953
Time	-0.05986	-8.553	-0.08158	-6.232	-0.11379	-9.539
Crops	0.21657	8.786	0.50512	15.723	0.42944	13.251
Livestock	0.78343	31.784	0.49488	15.404	0.57056	17.605
Plab	0.32982	74.119	0.33910	100.619	0.32283	65.294
Pcap	0.40447	112.896	0.41750	125.517	0.35785	125.288
Poth	0.26571	68.375	0.24339	73.688	0.31932	58.857
Plab2	-0.05074	-1.480	-0.13341	-3.849	-0.20525	-5.143
Plabcap	-0.17123	-9.141	-0.24540	-12.903	-0.19811	-14.662
Plaboth	0.22197	11.047	0.37881	18.186	0.40335	12.004
Pcap2	0.29681	20.847	0.36974	24.312	0.28909	26.247
Pcapoth	-0.12558	-11.243	-0.12434	-11.228	-0.09098	-6.848
Poth2	-0.09639	-6.484	-0.25447	-14.556	-0.31237	-9.672

System weighted MSE = 2.18147.
System weighted R^2 = 0.987545.
Degrees of freedom = 201.

Table 2-B

Cost Function Estimates Joint Generalized Least Squares - All Provinces Rental Rate for Land

	Alberta		Saskatchewan		Manitoba	
Variable	Parameter	T-statistic	Parameter	T-statistic	Parameter	T-statistic
Intercept	0.69430	38.510	0.95227	22.087	0.82334	31.142
Time	-0.05927	-8.532	-0.10451	-8.342	-0.12612	-10.411
Crops	0.23396	9.612	0.46489	15.869	0.39359	12.178
Livestock	0.76604	31.472	0.53511	18.265	0.60641	18.763
Plab	0.35227	67.840	0.34610	96.690	0.32241	60.928
Pcap	0.35577	91.809	0.40279	129.934	0.35738	121.616
Poth	0.29196	74.449	0.25111	72.295	0.32021	58.158
Plab2	-0.17786	-5.966	-0.27116	-8.216	-0.26663	-6.445
Plabcap	-0.07691	-3.718	-0.15875	-8.012	-0.17147	-11.818
Plaboth	0.25477	14.046	0.42991	21.069	0.43810	11.925
Pcap2	0.20583	10.349	0.29556	19.466	0.26732	20.039
Pcapoth	-0.12892	-9.533	-0.13681	-11.092	-0.09585	-6.090
Poth2	-0.12585	-8.046	-0.29310	-15 368	-0.34227	-9.192

System weighted MSE = 2.20712.
System weighted R^2 = 0.986864.
Degrees of freedom = 201.

Table 3

Marginal Unit Cost and Price of Output, Manitoba, 1961-1985

Year	Price	COST4	COSTR	COSTI4	COSTIR
1961	70.242	100.107	100.716	42.113	44.757
1962	74.610	103.802	105.451	47.076	50.351
1963	75.323	99.364	101.659	44.684	48.146
1964	72.315	96.841	99.458	44.902	48.280
1965	68.149	88.425	90.869	43.172	46.236
1966	68.544	85.714	88.135	44.917	47.775
1967	63.793	86.412	88.118	45.528	47.582
1968	61.928	89.226	90.364	48.215	49.712
1969	74.805	104.820	107.089	52.907	55.095
1970	72.923	98.664	101.144	49.367	51.275
1971	64.781	97.818	99.209	51.334	52.559
1972	78.844	105.804	110.038	57.449	61.140
1973	133.465	128.167	131.764	72.605	75.707
1974	163.760	144.583	146.340	79.829	80.955
1975	135.535	140.716	145.987	79.718	84.561
1976	117.201	137.545	140.325	81.935	84.326
1977	112.352	143.636	143.091	87.290	86.153
1978	124.150	159.711	157.344	96.177	93.305
1979	166.763	202.219	197.793	116.355	111.371
1980	161.526	203.208	198.544	116.735	111.407
1981	182.532	235.395	231.728	133.445	129.695
1982	171.628	241.435	240.821	139.628	139.059
1983	180.068	262.735	263.809	163.490	164.550
1984	194.008	271.057	272.373	167.007	168.183
1985	172.001	264.289	267.654	160.980	164.033

Notes:
- Output includes both crops and livestock;
- COST4 - total cost including all imputations and 4 per cent real cost for land;
- COSTR - total cost including all imputations and rental cost of land;
- COSTI4 and COSTIR - same as above but excluding imputed labour costs and carrying cost of machinery and equipment and inventories.

Table 4

Marginal Unit Cost and Price of Output, Saskatchewan, 1961-1985

Year	Price	COST4	COSTR	COSTI4	COSTIR
1961	61.646	76.317	72.083	28.928	27.354
1962	62.797	71.906	69.724	27.270	26.931
1963	65.260	76.364	75.713	29.634	30.422
1964	63.088	78.020	79.346	31.046	33.357
1965	58.332	75.182	78.630	32.073	36.155
1966	58.462	73.598	79.344	35.497	41.794
1967	58.916	78.832	82.863	38.911	43.391
1968	53.127	79.697	82.285	38.711	41.646
1969	56.782	91.217	93.211	40.274	42.515
1970	70.556	113.755	114.332	50.968	51.791
1971	60.427	99.881	99.285	47.318	46.852
1972	67.238	104.159	106.659	50.382	52.722
1973	120.521	121.894	123.882	58.593	60.343
1974	155.843	134.946	135.573	62.422	62.646
1975	132.138	143.292	147.102	73.388	76.736
1976	103.583	132.001	133.134	70.451	70.988
1977	101.884	148.023	146.231	80.746	78.148
1978	122.922	171.139	168.304	92.602	88.893
1979	173.100	212.028	206.577	110.319	103.876
1980	175.652	225.780	216.869	122.944	112.606
1981	195.243	253.971	249.014	134.747	128.839
1982	165.942	258.195	251.571	145.249	137.174
1983	174.218	279.058	273.448	166.021	158.768
1984	186.582	280.744	274.240	163.049	154.691
1985	167.012	275.245	272.856	165.950	161.595

Notes:
- Output includes both crops and livestock;
- COST4 - total cost including all imputations and 4 per cent real cost for land;
- COSTR - total cost including all imputations and rental cost of land;
- COSTI4 and COSTIR - same as above but excluding imputed labour costs and carrying cost of machinery and equipment and inventories.

Table 5

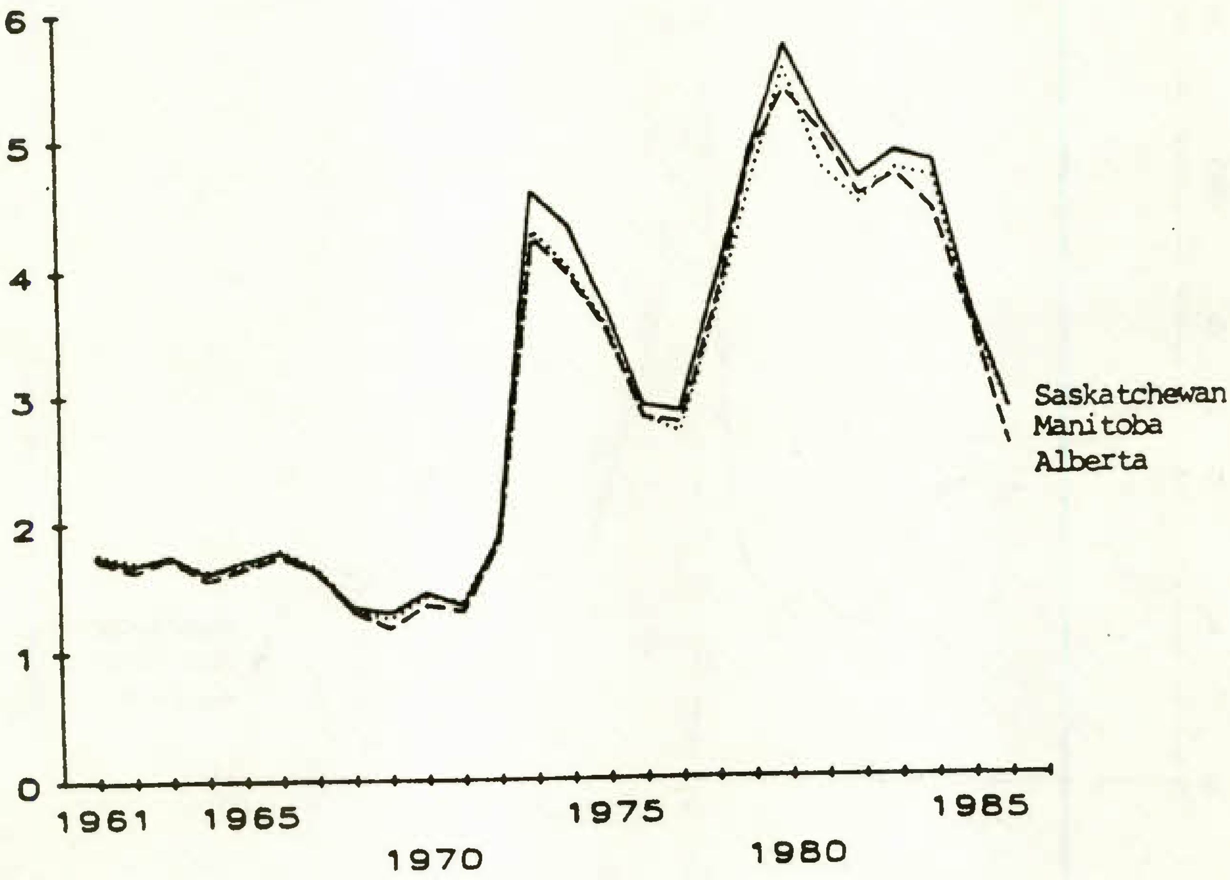
Marginal Unit Cost and Price of Output,
Alberta, 1961-1985

Year	Price	COST4	COSTR	COSTI4	COSTIR
1961	61.910	91.303	97.281	39.739	43.609
1962	61.646	82.511	87.280	36.546	39.803
1963	69.976	93.334	98.108	41.927	45.292
1964	65.377	90.927	95.444	42.233	45.631
1965	65.304	92.572	96.904	45.290	48.734
1966	58.480	77.809	81.478	38.888	41.836
1967	62.011	87.927	90.163	45.036	46.672
1968	53.742	82.719	83.427	43.272	43.488
1969	60.172	99.048	98.595	48.529	47.705
1970	74.501	128.205	124.824	60.218	57.137
1971	69.530	119.483	116.126	57.272	53.979
1972	82.289	133.914	130.210	67.750	64.180
1973	133.359	161.445	154.716	82.303	76.044
1974	141.739	161.313	150.902	83.265	73.996
1975	111.054	142.001	134.156	79.622	72.440
1976	93.527	134.109	124.467	75.572	66.730
1977	93.215	142.847	129.569	87.725	74.847
1978	117.314	182.626	165.030	107.956	90.941
1979	155.085	231.515	201.749	133.178	104.838
1980	151.348	245.609	210.513	142.298	109.279
1981	172.683	279.317	244.406	154.828	124.167
1982	156.165	268.295	236.136	158.945	129.142
1983	159.272	286.845	255.473	175.589	146.194
1984	180.421	296.102	265.231	175.329	147.001
1985	159.139	284.741	256.901	178.051	152.164

Notes:
- Output includes both crops and livestock;
- COST4 - total cost including all imputations and 4 per cent real cost for land;
- COSTR - total cost including all imputations and rental cost of land;
- COSTI4 and COSTIR - same as above but excluding imputed labour costs and carrying cost of machinery and equipment and inventories.

Chart 1

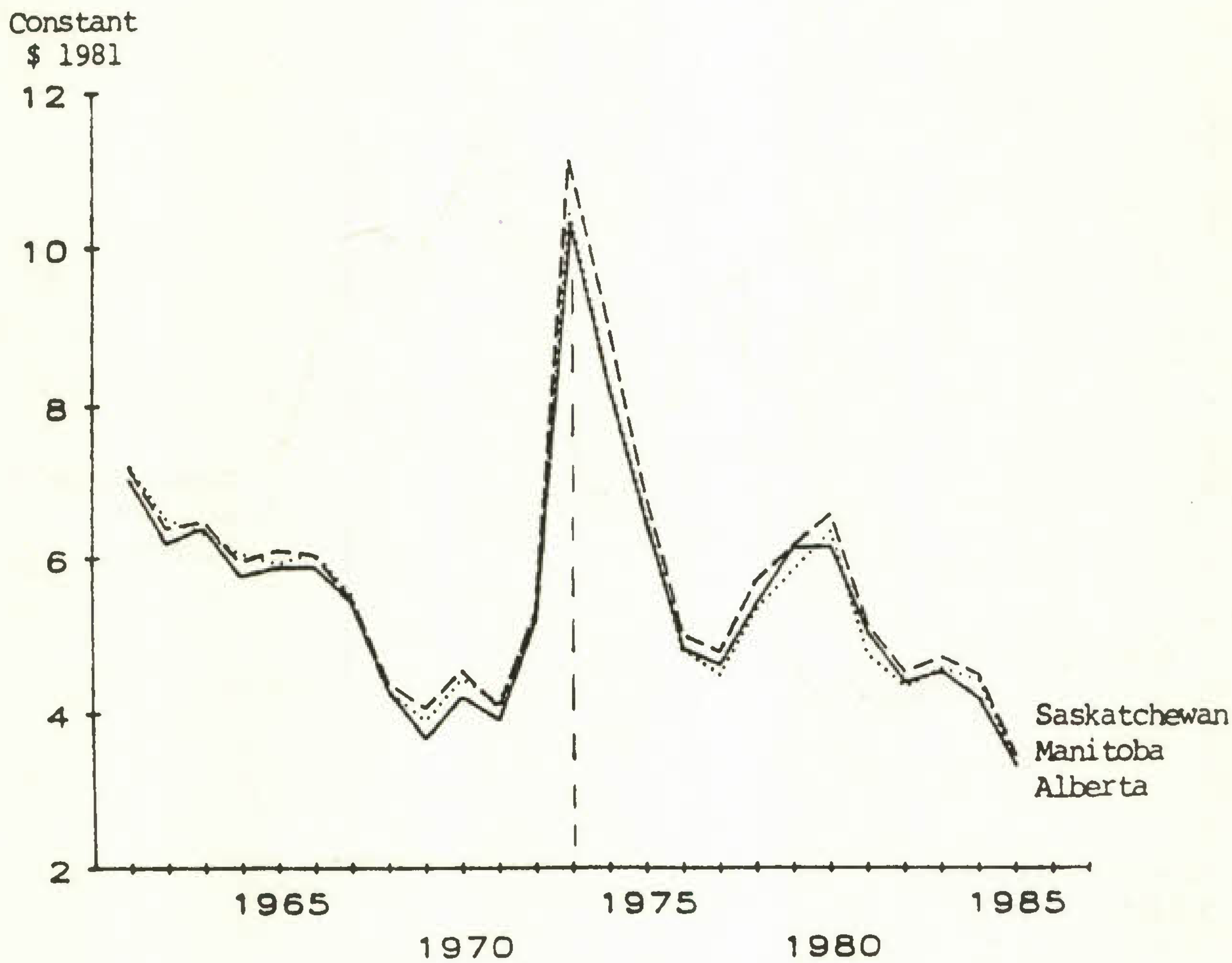
Price of Wheat per Bushel, Prairie Provinces, 1961-86



Source: Based on data from Statistics Canada.

Chart 2

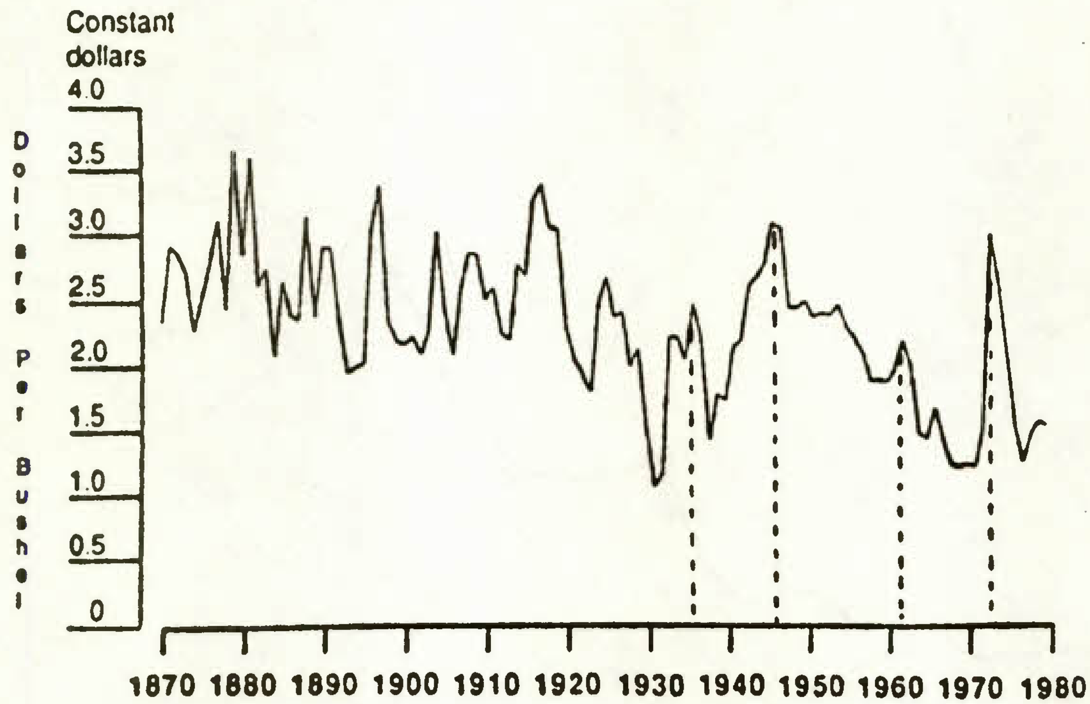
Wheat Prices Received by Farmers, Prairie Provinces, 1961-85



Source: Based on data from Statistics Canada.

Chart 3

Wheat Prices Received by Farmers, 1870-1980

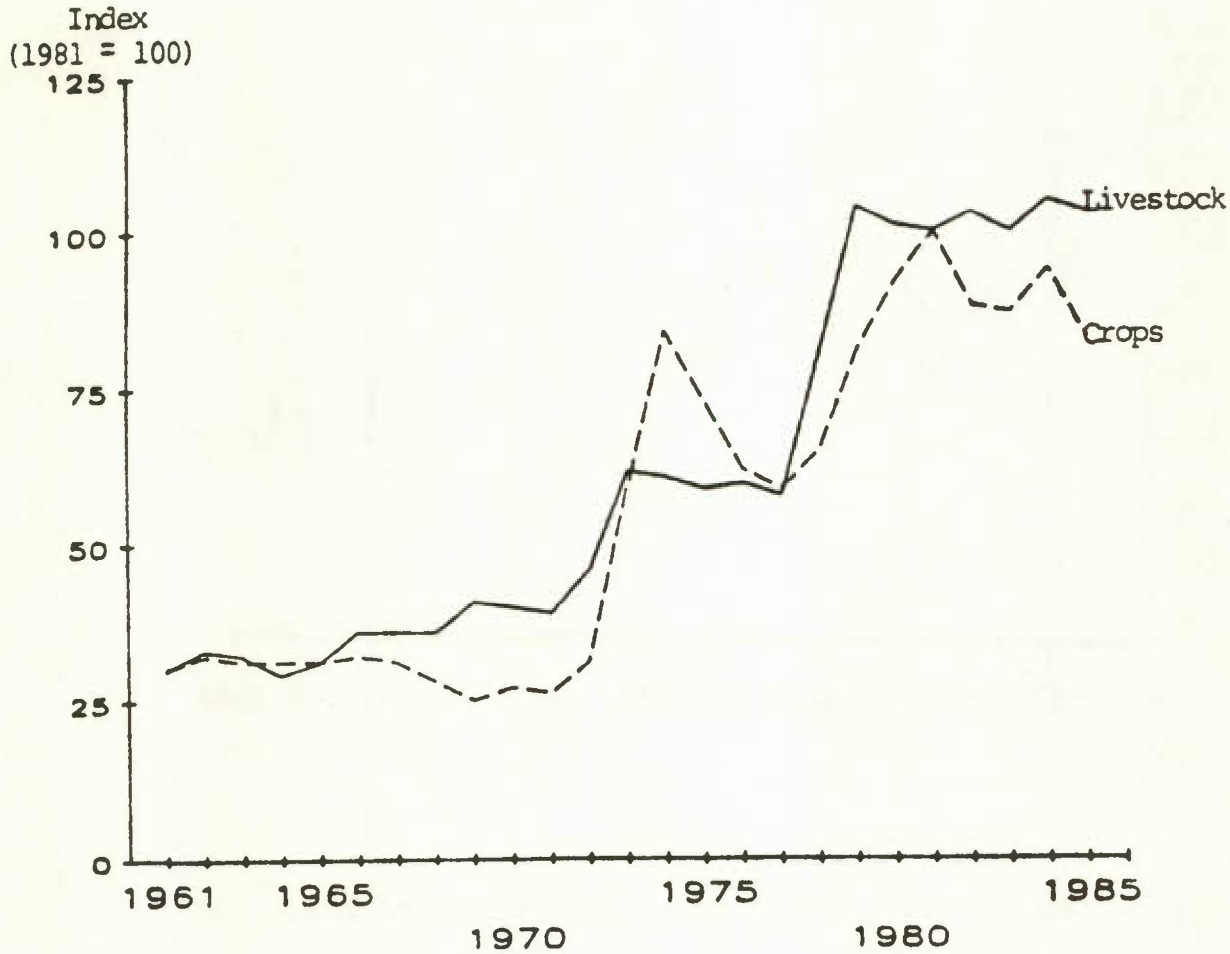


Source D. G. Johnson, World Grain Trade Beyond 2000.

(Reproduced with permission of the author.)

Chart 4

Prices of Crops and Livestock, Prairie Region, 1961-85

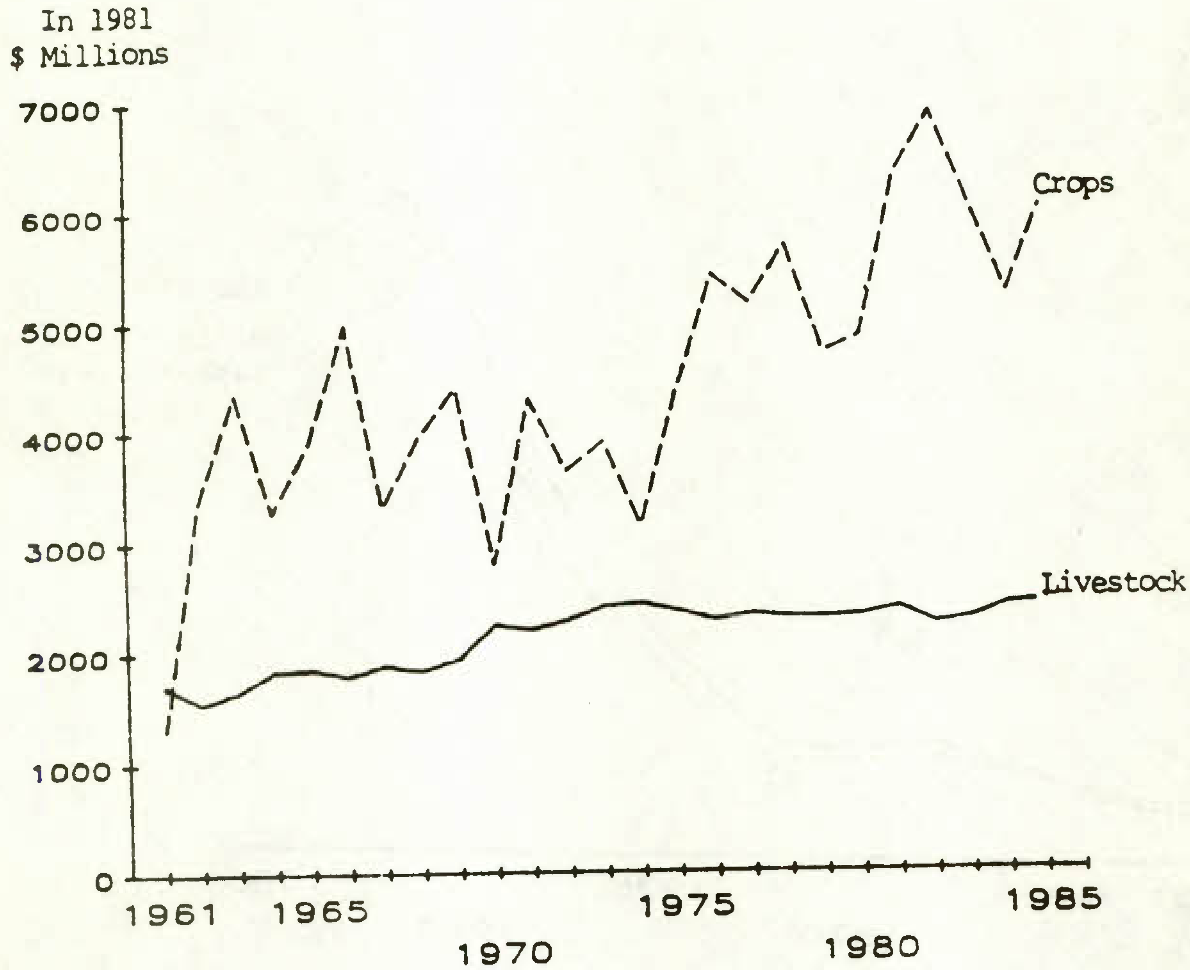


Crops include wheat, oats, barley, rye, flaxseed and canola.
Livestock does not include livestock products.

Source: Estimates based on data from Statistics Canada.

Chart 5

Production of Crops and Livestock, Prairie Region, 1961-85

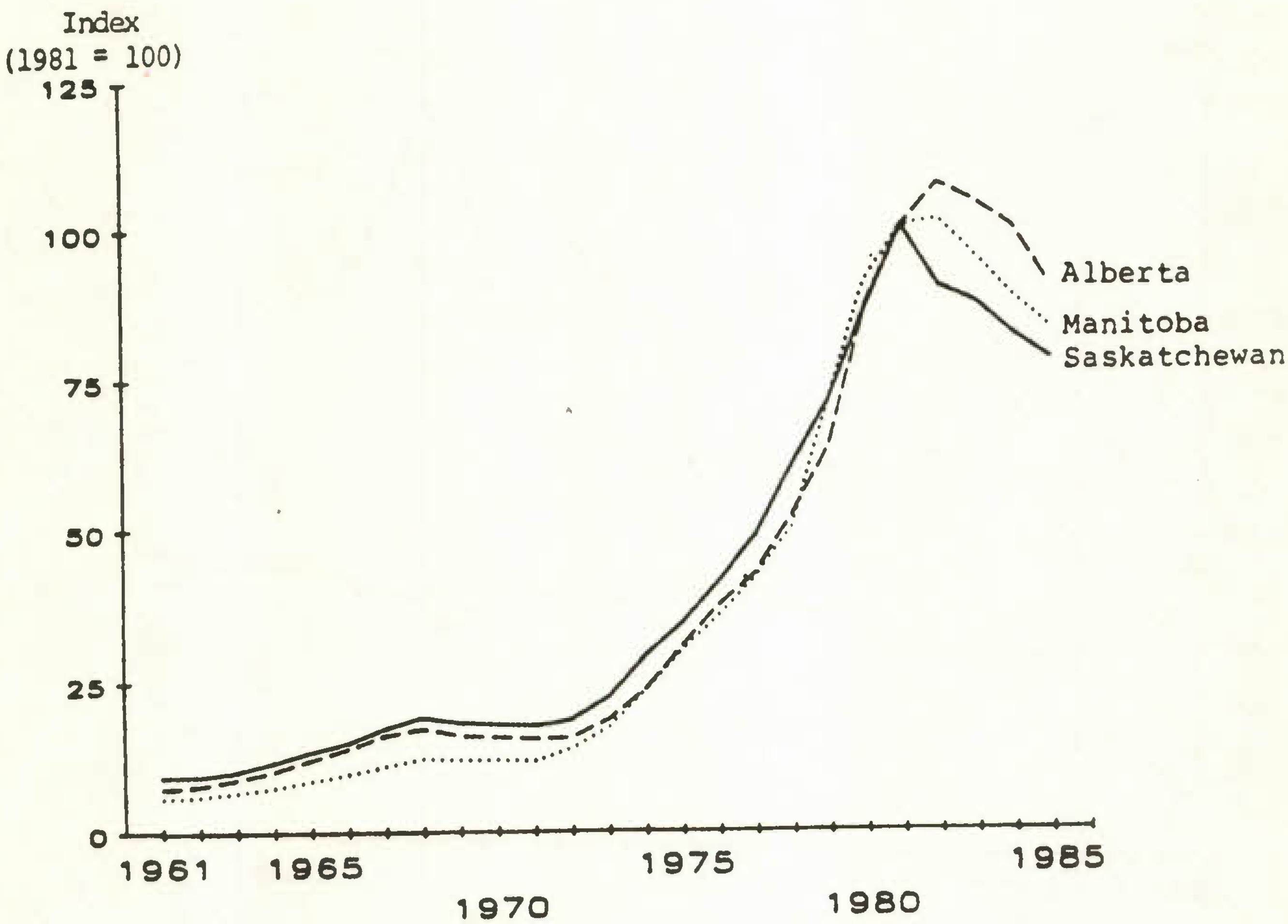


Crops include wheat, oats, barley, rye, flaxseed, and canola.
Production excludes intermediate inputs and livestock products.

Source: Estimates based on data from Statistics Canada.

Chart 6

Price of Farm Land per Acre, Prairie Provinces, 1961-86

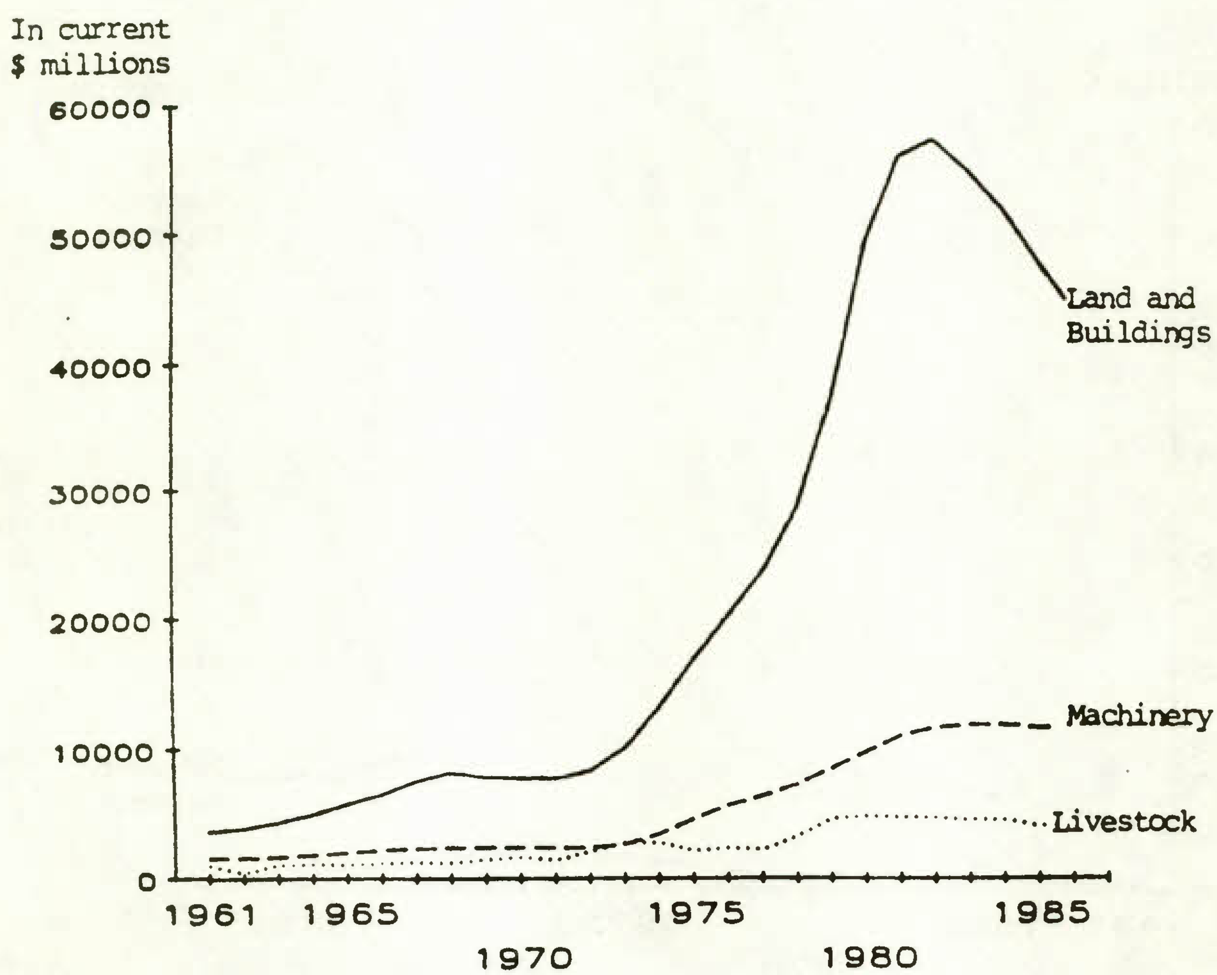


Farm land includes land and buildings.

Source: Based on data from Statistics Canada.

Chart 7

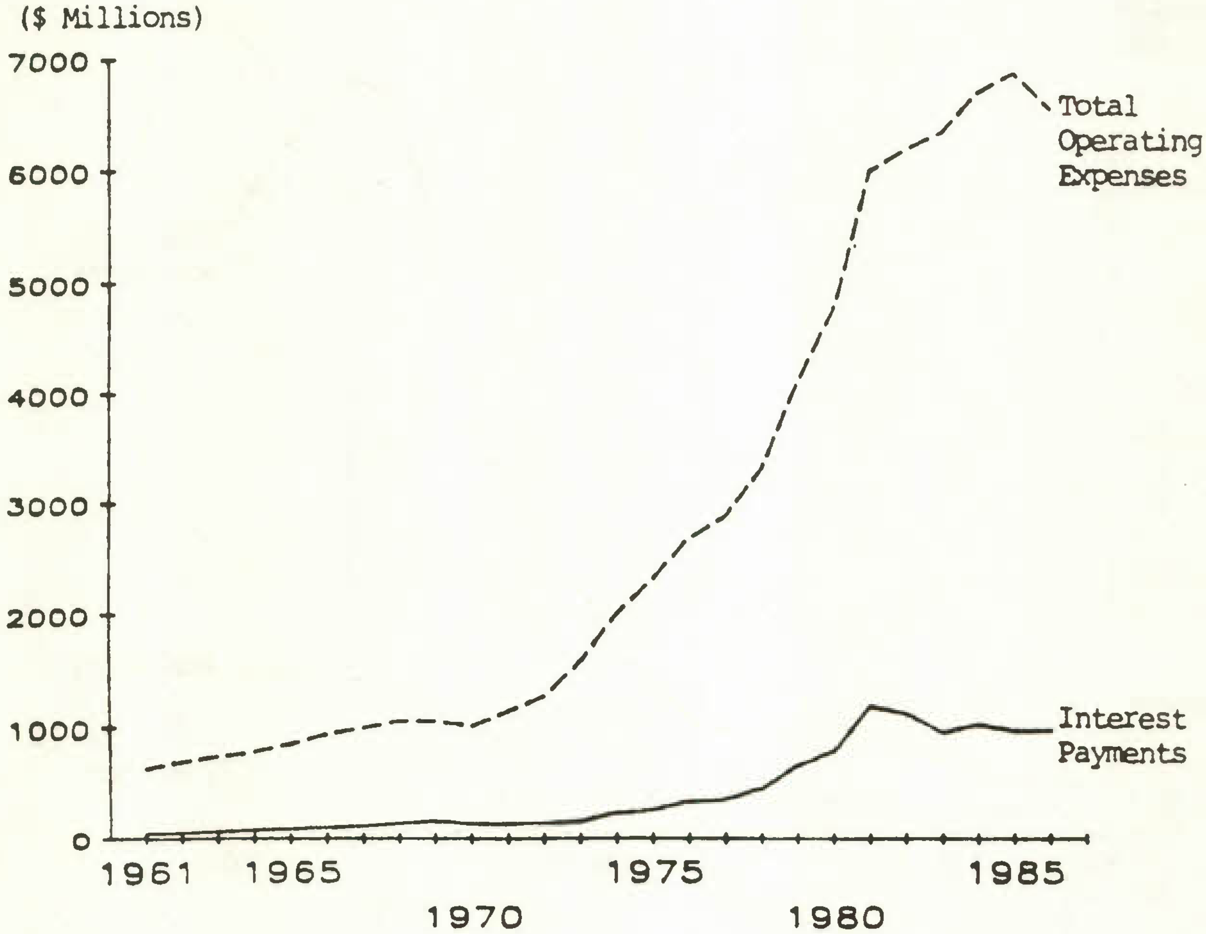
Farm Capital, Prairie Region, 1961-86



Source: Estimates based on data from Statistics Canada.

Chart 8

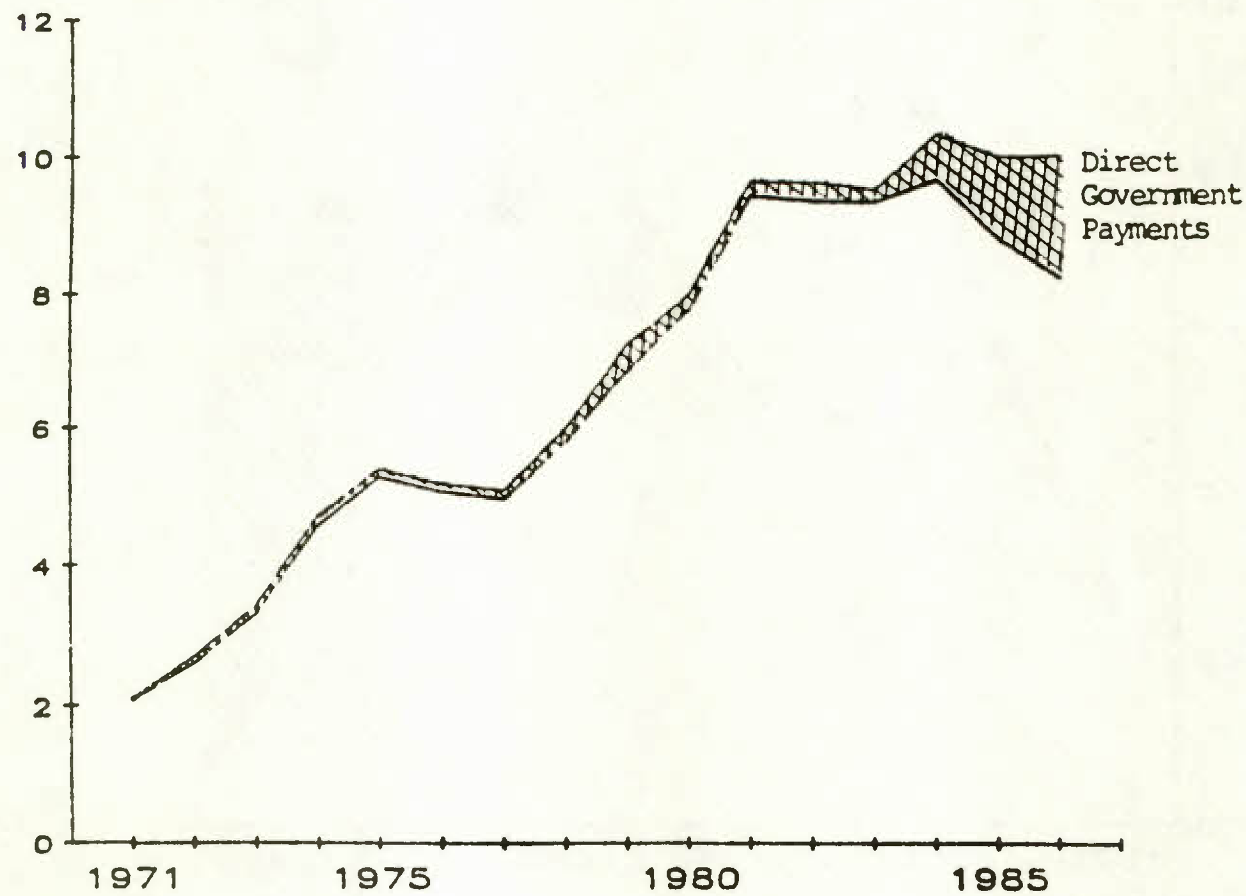
Interest Payments and Cash Operating Expenses, Prairie Region, 1961-86



Source: Estimates based on data from Statistics Canada.

Chart 9

Direct Government Payments as Part of Realized Gross Income of Farms, Prairie Region, 1971-86

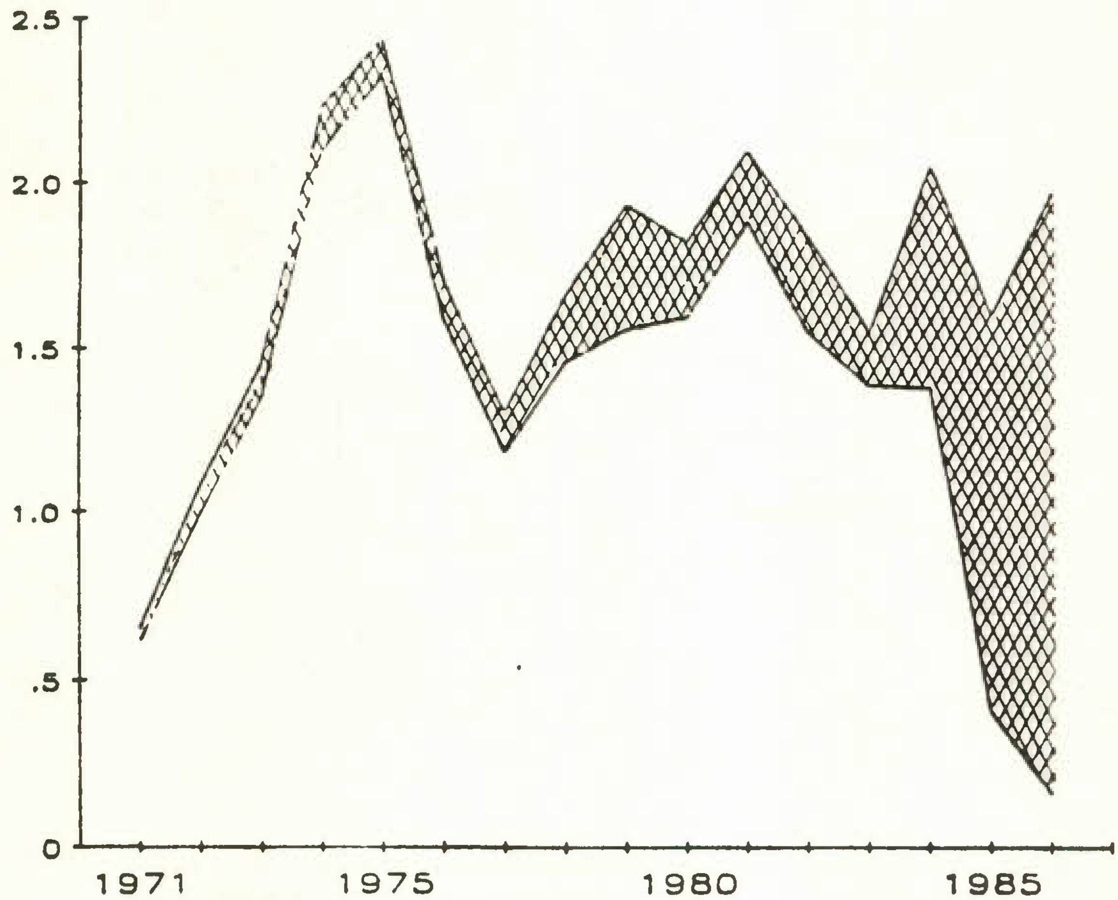


Realized gross income includes receipts from farm operations, income in kind, and supplementary payments. It is income before farm expenditures.

Source: Based on data from Statistics Canada.

Chart 10

Direct Government Payments as Part of Realized
Net Income of Farms, Prairie Region, 1971-86

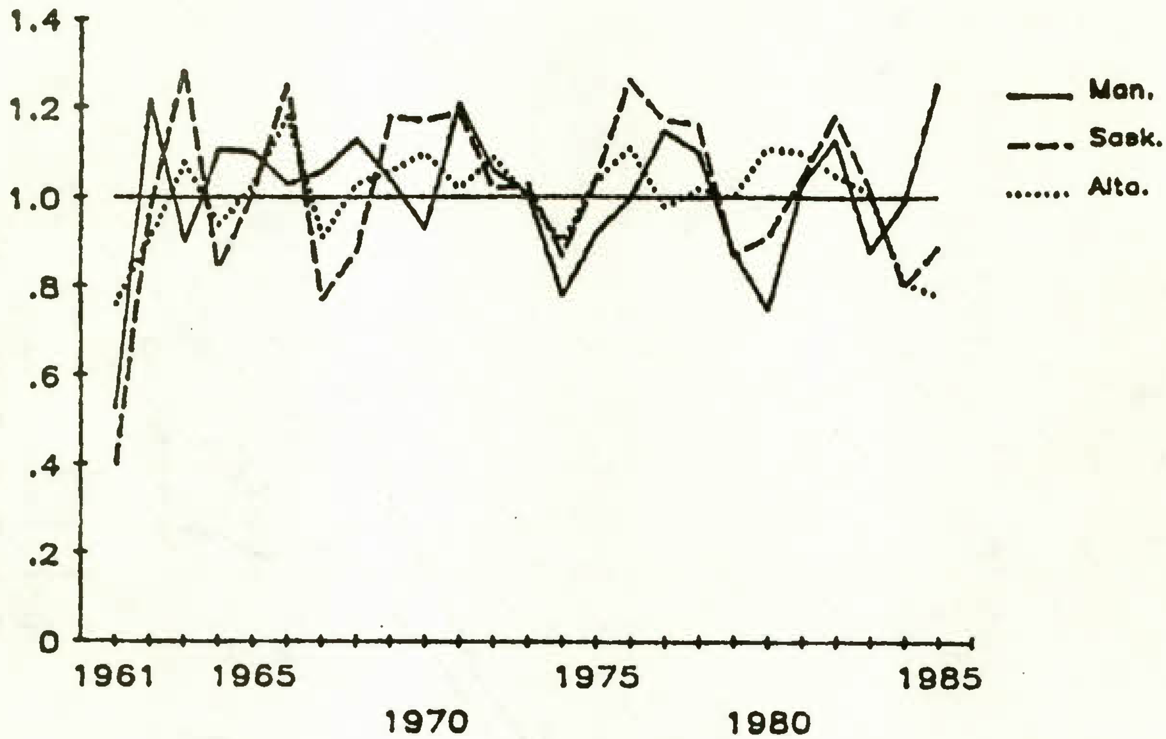


Realized net income includes receipts from farm operations, income in kind, and supplementary payments as well as farm operating expenditures and depreciation.

Source: Based on data from Statistics Canada.

Chart 11

Crop Adjustment Factors for Weather,
Prairie Provinces, 1961-85



Source R. Wisner, "Weather and Crop Yields in the Prairie Provinces, 1961-85," Economic Council of Canada, Discussion Paper (forthcoming), December 1987, Appendix C, Tables 1, 5, 9, Series W2.

Chart 12

Total Costs, Manitoba, 1961-85

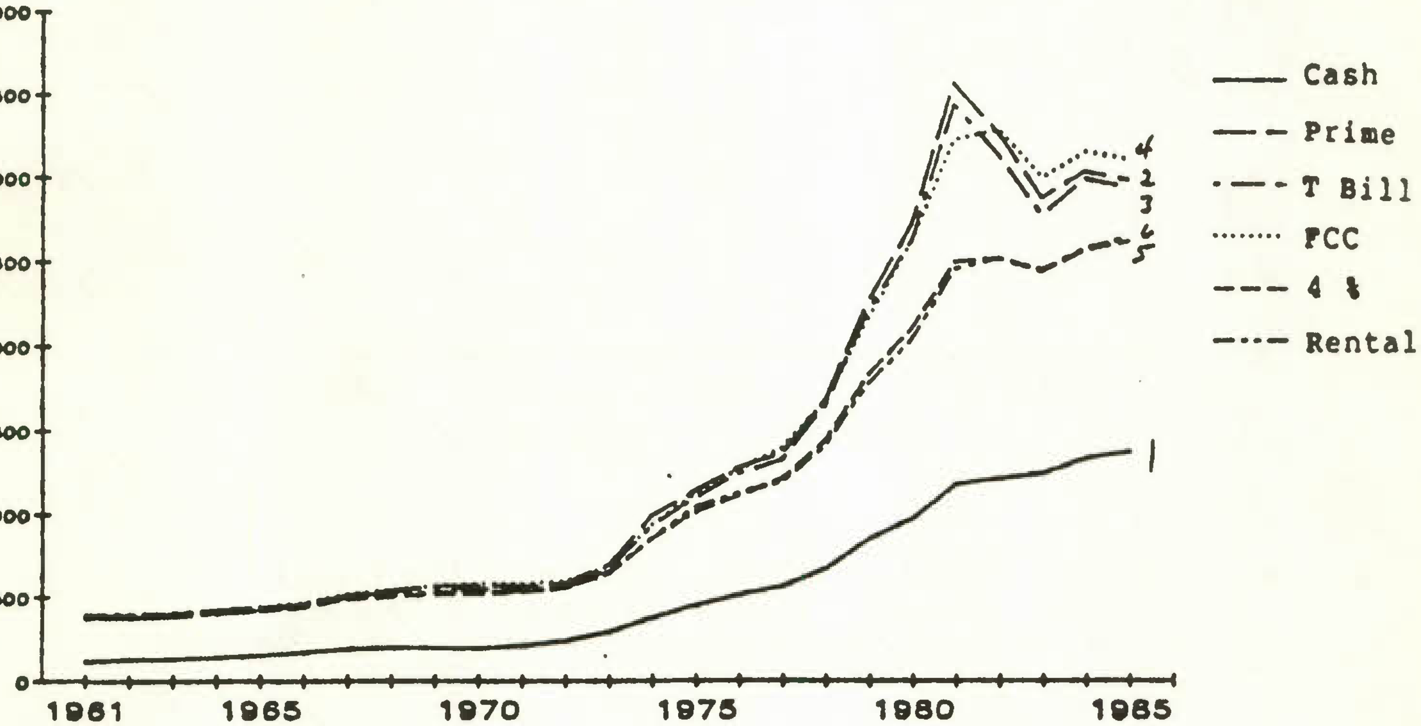


Chart 13

Total Costs, Saskatchewan, 1961-85

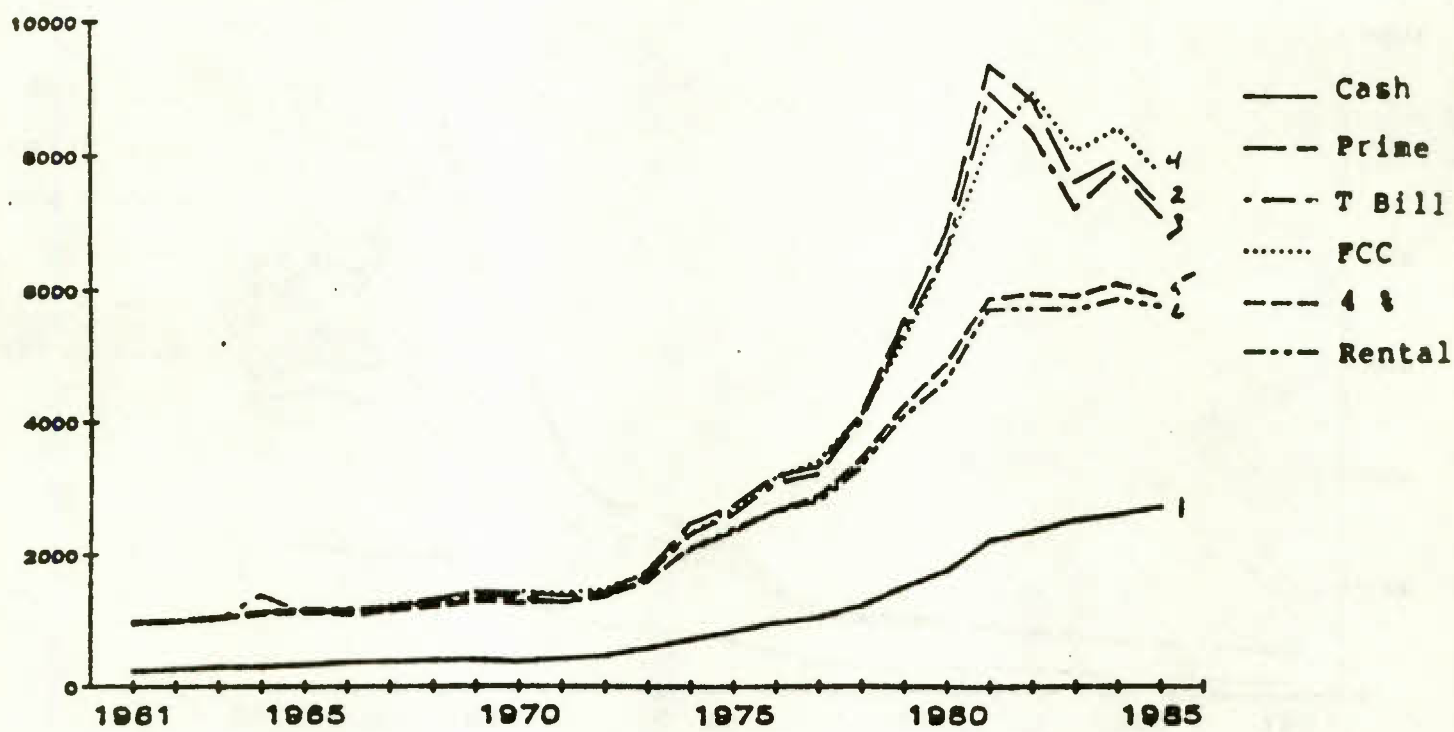


Chart 14

Total Costs, Alberta, 1961-85

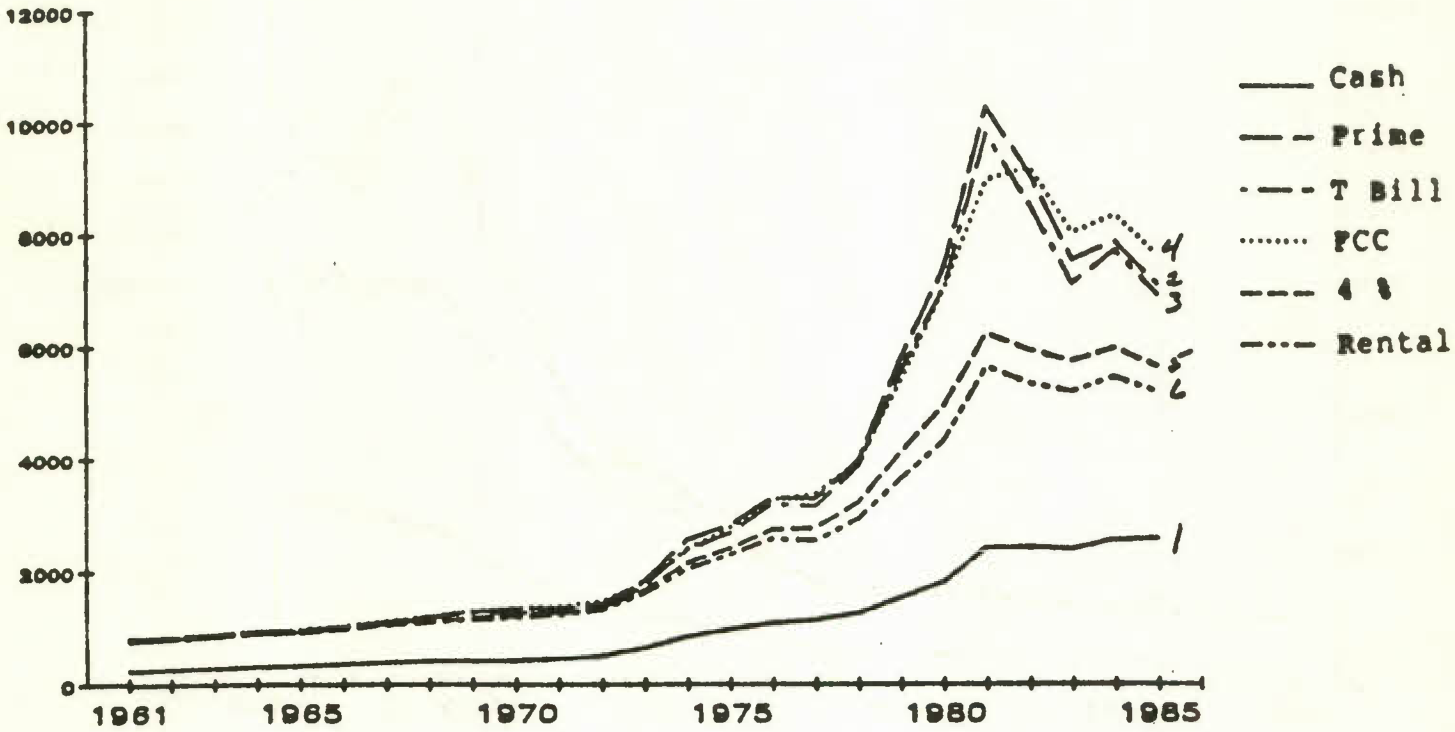


Chart 15

Marginal Unit Cost and Price of Output,
Manitoba, 1961-85

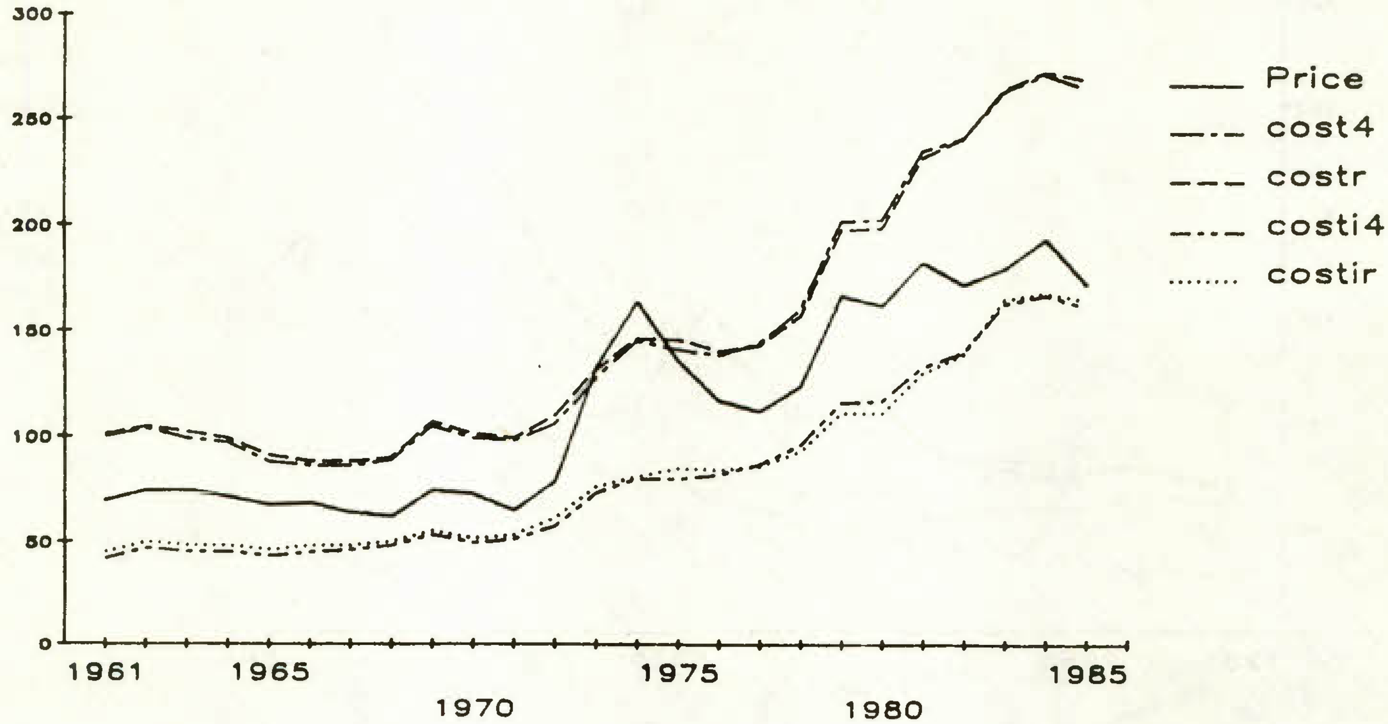


Chart 16

Marginal Unit Cost and Price of Output,
Saskatchewan, 1961-85

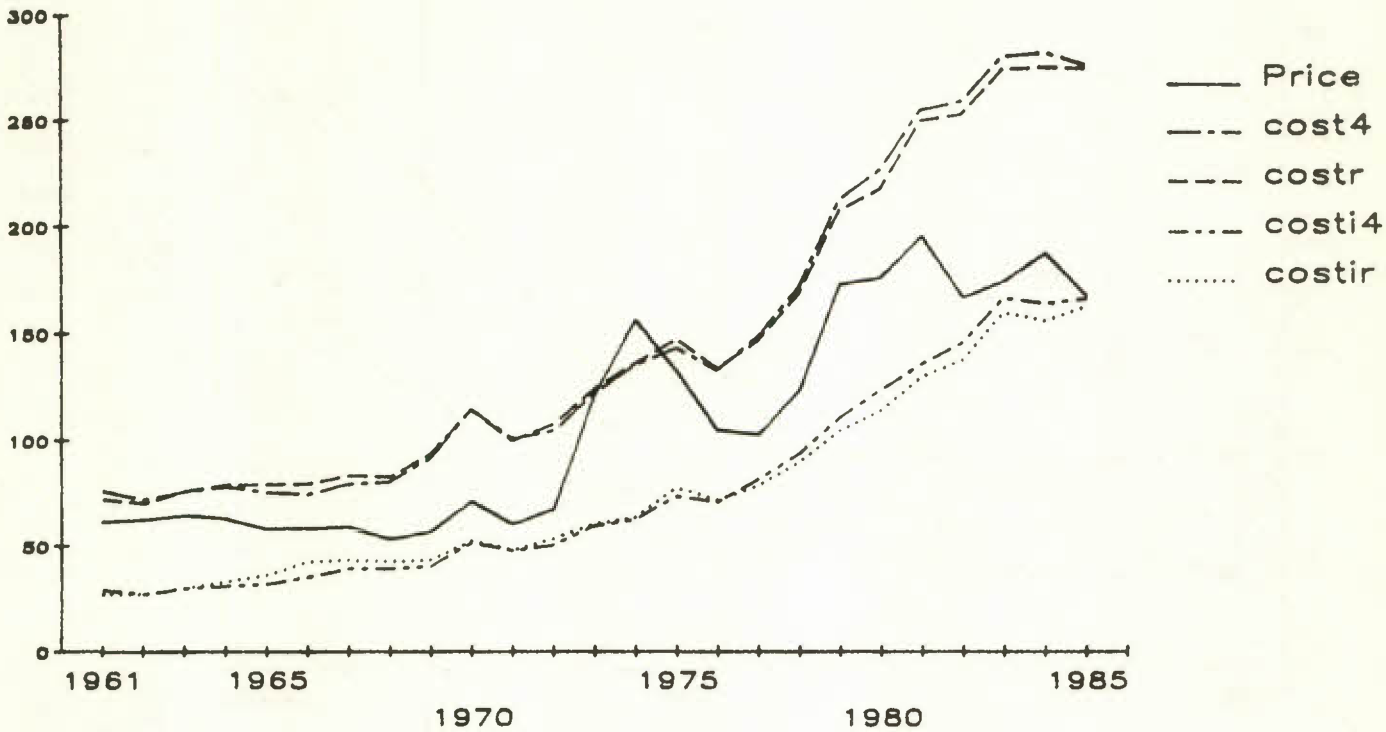
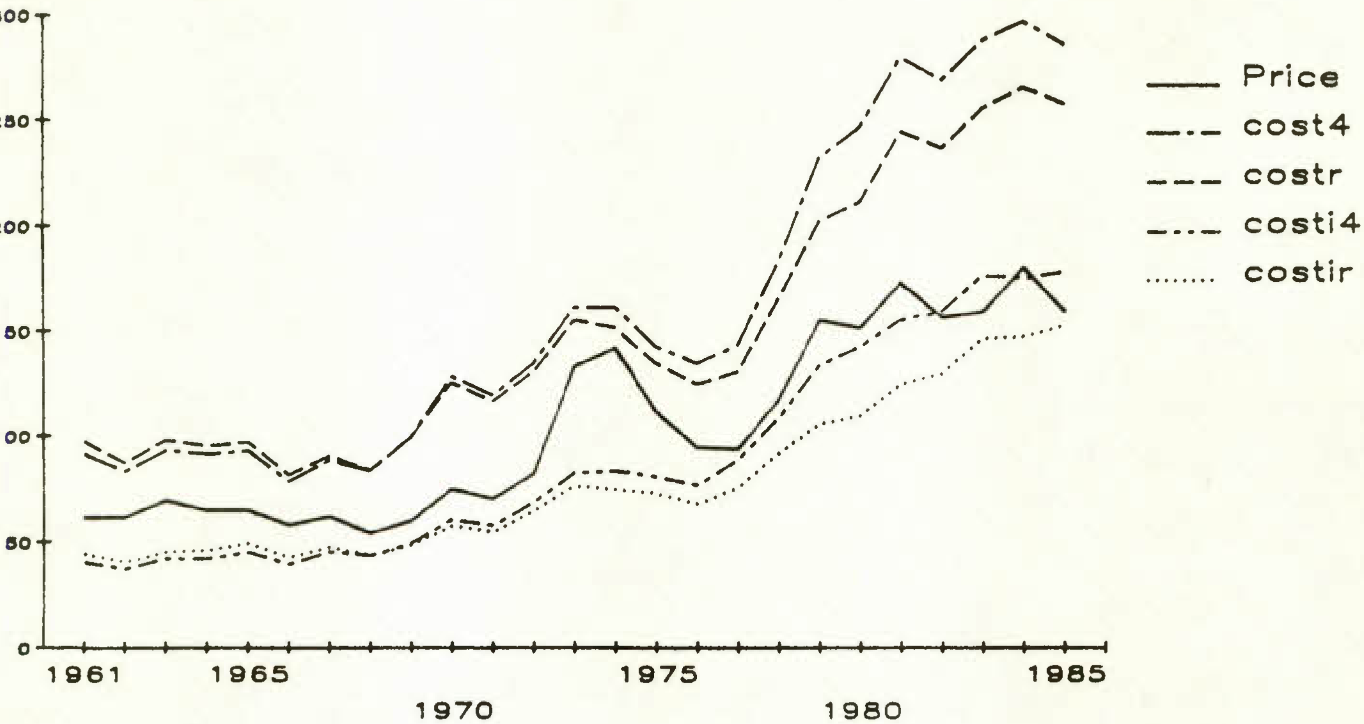


Chart 17

Marginal Unit Cost and Price of Output,
Alberta, 1961-85



APPENDIX A

OBTAINING A MINIMUM VARIANCE UNBIASED ESTIMATE OF THE MEAN COST FROM A TRANSLOG COST FUNCTION

This appendix follows the development for a single equation given in Goldberger (1968) adapted to the problem specified in the text.

1 Preliminaries

Let $u \sim N(\mu, \sigma^2)$ and let $U = e^u$. Then, U is log normally distributed with mean

$$E\{U\} = E\{e^u\} = e^{\mu + \frac{1}{2}\sigma^2}$$

That is, $E\{U\}$ is the moment generating function of u.

Lemma: Let $\nu w/\sigma^2$ be distributed as χ^2_ν, where w is a random variable, ν is a positive integer, and σ^2 is a positive parameter. For a given constant c, an unbiased estimator of $e^{c\sigma^2}$ is given by the function

$$F(w;\ \nu,\ c) = \sum_{j=0}^{\infty} \frac{f_j\ (cw)^j}{j!}$$

where

$$f_j = \frac{(\frac{1}{2}\nu)^j \, \Gamma\,(\frac{1}{2}\nu)}{\Gamma(\frac{1}{2}\nu+j)}$$

and $\Gamma(\alpha)$ is the gamma function. If α is a positive integer, then $\Gamma(\alpha)=(\alpha-1)!$.

2 Translog Cost Function

The translog cost function may be written

$$C_t = e^{X_t\beta} \, U_t \qquad t = 1, 2, \ldots\ldots, T$$

Taking logarithms yields the linear form

$$c_t = X_t\beta + u_t \qquad t = 1, 2, \ldots\ldots, T \tag{1}$$

where $c_t = \ln(C_t)$, $u_t = \ln(U_t)$, and the vector of individual disturbances, u, is assumed distributed $u \sim N(0, \sigma^2 I)$

Thus, $E\{c_t\} = X_t\beta$, and $\text{var}(c_t) = \sigma^2$, with c_t being distributed, $c_t \sim N(X_t\beta, \sigma^2)$.

On the other hand, $C_t = e^{c_t}$, and

$$E\{C_t\} = E\{e^{c_t}\} = \exp\{X_t\beta + \tfrac{1}{2}\sigma^2\}$$

Thus, exponentiation of the mean value of c_t does not give an unbiased value for the mean of C_t.

Following standard procedure, the log form of the cost function (1) along with several other equations are estimated by a seemingly unrelated regression. Suppose we have a system of m equations, each with T observations which we shall write in matrix form,

$$\begin{matrix} y_1 & = & X_1\beta_1 & + & u_1 \\ \vdots & & \vdots & & \vdots \\ y_m & = & X_m\beta_m & + & u_m \end{matrix}$$

where the error terms of the individual equations are assumed distributed, $u_i \sim N(0, \sigma_{ii}I_T)$, but are contemporaneously related to one another by a covariance matrix $\sigma^2\Sigma$, where

$$\sigma^2 = 1, \quad \Sigma = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \cdots & \sigma_{1m} \\ \sigma_{21} & \sigma_{22} & \cdots & \sigma_{2m} \\ \vdots & \vdots & & \vdots \\ \sigma_{m1} & \sigma_{m2} & \cdots & \sigma_{mm} \end{bmatrix}, \text{ and } \sigma_{ij} = \sigma_{ji} = E\{u_{it}u_{jt}\}$$

To simplify notation, let

$$y = \begin{bmatrix} y_1 \\ \vdots \\ y_m \end{bmatrix}, \quad X = \begin{bmatrix} X_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & X_m \end{bmatrix}; \quad \beta = \begin{bmatrix} \beta_1 \\ \vdots \\ \beta_m \end{bmatrix}; \quad u = \begin{bmatrix} u_1 \\ \vdots \\ u_m \end{bmatrix}.$$

The entire system of m equations may then be compactly written

$$y = X\beta + u$$

where $E\{u\} = 0$, and $\text{cov}(u) = \sigma^2 \Sigma \otimes I_T$, with the normalization $\sigma^2 = 1$. The non-logged values of the dependent variable are obtained by the exponentiation

$$Y = e^y = \exp\{X\beta + u\}$$

with the mean value of Y being given by

$$E\{Y\} = E\{e^y\} = \exp\{X\beta + \tfrac{1}{2}\sigma^2 dg\ (\Sigma \otimes I_T)\}$$

The first step in the joint GLS procedure is to estimate each equation separately by OLS. The equation residuals are then used to construct a matrix S as an estimator of Σ. (The matrix S is not an unbiased estimator of Σ although it could be made so. However, even is S were an unbiased estimator of Σ, S^{-1} would not be an unbiased estimator of Σ^{-1}. For details see, for example, Theil (1977), pp. 321-322.) Because of the intractability of obtaining unbiased estimators, in what follows S is considered to be a fixed and known matrix of weights, and the entire procedure must therefore be considered only approximate.

The second step of the procedure involves estimating the entire system of equations by GLS with restrictions applied to the parameters. The parameter restrictions are expressed in familiar fashion by

$$R\beta = r$$

where each row of the matrix R represents one restriction and each element of the vector r is a numerical value. The joint GLS estimator is given by

$$\hat{\beta} = (X' (S^{-1} \otimes I) X)^{-1} X'(S^{-1} \otimes I) y$$

$$- (X' (S^{-1} \otimes I) X)^{-1} R'(R (X' (S^{-1} \otimes I) X)^{-1} R')^{-1} \cdot$$

$$(R (X' (S^{-1} \otimes I) X)^{-1} X' (S^{-1} \otimes I) y - r)$$

and $$\hat{\sigma}^2 = \frac{(y-X\hat{\beta})' (y-X\hat{\beta})}{mT - \sum_{i=1}^{m} k_i - g}$$

where mT is the total number of observations (m equations each with T observations), k_i is the number of explanatory variables in the i^{th} equation, and g is the number of restrictions imposed by R.

Setting $\hat{y} = X\hat{\beta}$, substituting $y = X\beta + u$, and $R\beta - r = 0$, yields

$$\hat{y} = X\beta + X\,(X'\,(S^{-1}\otimes I)\,X)^{-1}\,X'\,(S^{-1}\otimes I)\,u$$

$$- X\,(X'\,(S^{-1}\otimes I)\,X)^{-1}\,R'\,(R\,(X'\,(S^{-1}\otimes I)\,X)^{-1}\,R')^{-1}\cdot$$

$$R\,(X'\,(S^{-1}\otimes I)\,X)^{-1}\,X'\,(S^{-1}\otimes I)\,u$$

Thus, $E\{\hat{y}\} = X\beta$ and the variance-covariance matrix of $\hat{y}$ is given by

$$\mathrm{cov}(\hat{y}) = \sigma^2[X\,(X'\,(S^{-1}\otimes I)\,X)^{-1}\,X'$$

$$- X\,(X'\,(S^{-1}\otimes I)\,X)^{-1}\,R'\,(R\,(X'\,(S^{-1}\otimes I)\,X)^{-1}\,R')^{-1}\,R$$

$$\cdot\,(X'\,(S^{-1}\otimes I)\,X)^{-1}\,X']$$

Transforming by $\hat{Y} = e^{\hat{y}}$ yields an estimator whose mean, $E\{\hat{Y}\}$, is a biased estimator of $E\{Y\}$. To invoke the lemma given previously, set $w = \hat{\sigma}^2$, $\nu = mT - \sum_{i=1}^{m} k_i - g$, and

$$c = \tfrac{1}{2}dg\,[(S \otimes I) - X\,(X'\,(S^{-1} \otimes I)\,X)^{-1}\,X'$$

$$+ X\,(X'\,(S^{-1} \otimes I)\,X)^{-1}\,R'\,(R\,(X'\,(S^{-1} \otimes I)\,X)^{-1}\,R')^{-1}$$

$$\cdot\, R\,(X'\,(S^{-1} \otimes I)\,X)^{-1}\,X']$$

Then, $F(w;\ \nu,c) = F\,(\hat{\sigma}^2;\ mT - \sum_{i=1}^{m} k_i - g,\ c)$

$$= \sum_{j=0}^{m} \frac{f_j}{j!}\,(\hat{\sigma}^2 c)^j$$

and by the lemma $E\,\{F\,(w;\ \nu,c)\} = e^{\sigma^2 c}$

Set

$$\tilde{Y} = \hat{Y} \cdot F(w;\ \nu,c)$$

and take expected values

$$E\,\{\tilde{Y}\} = E\,\{\hat{Y} \cdot F(w;\ \nu,c)\}$$

$$= E\,\{\hat{Y}\} \cdot E\,\{F\,(w;\ \nu,c)\}$$

because of the independence of $\hat{\beta}$ and $\hat{\sigma}^2$.

Substituting on the right hand side and simplifying yields

$$E\{\tilde{Y}\} = \exp\{X\beta + \tfrac{1}{2}\sigma^2 dg\ (S \otimes I)\}$$

which we shall use as the unbiased estimate of the mean of Y.

Several steps are required to calculate $\tilde{Y}$, however most of the information required has been generated by the regression procedure. Furthermore, since the matrix X is block diagonal, the expression for $\tilde{Y}$ may be easily decomposed into a separate expression for each equation, and thus only the cost equations need to be considered.

From the regression we have an estimate of the variance-covariance matrix of β given by

$$\mathrm{Cov}(\hat{\beta}) = \hat{\sigma}^2\ [X'\ (S^{-1} \otimes I)\ X)^{-1} - (X'\ (S^{-1} \otimes I)\ X)^{-1} \cdot$$

$$R'\ (R\ (X'\ (S^{-1} \otimes I)\ X)^{-1}\ R')^{-1}\ R\ (X'\ (S^{-1} \otimes I)\ X)^{-1}]$$

Partition this matrix conformally with the parameters of each equation

$$\text{Cov}(\hat{\beta}) = \begin{bmatrix} \text{cov}(\hat{\beta}_1) & \text{cov}(\hat{\beta}_1\hat{\beta}_2) & \cdots & \text{cov}(\hat{\beta}_1\hat{\beta}_m) \\ \text{cov}(\hat{\beta}_1\hat{\beta}_2) & \text{cov}(\hat{\beta}_2) & \cdots & \text{cov}(\hat{\beta}_2\hat{\beta}_m) \\ \vdots & \vdots & & \vdots \\ \text{cov}(\hat{\beta}_1\hat{\beta}_m) & \text{cov}(\hat{\beta}_2\hat{\beta}_m) & \cdots & \text{cov}(\hat{\beta}_m) \end{bmatrix}$$

From the first stage of the regression procedure we have the matrix S, given by

$$S = \begin{bmatrix} s_{11} & s_{12} & \cdots & s_{1m} \\ s_{21} & s_{22} & \cdots & s_{2m} \\ \vdots & \vdots & & \vdots \\ s_{m1} & s_{m2} & \cdots & s_{mm} \end{bmatrix}$$

Then

$$F(w;\ \nu,c) = \sum_{j=0}^{\infty} \frac{f_j}{j!} (\hat{\sigma}^2 c)^j$$

for the entire system is given by

$$F(w;\ \nu,c) = \sum_{j=0}^{\infty} \frac{f_j}{j!} (\tfrac{1}{2}\text{dg}\ [\hat{\sigma}^2\ (S\otimes I) - X\text{cov}(\hat{\beta})\ X'])^j\ ,$$

while for the T observations of the i^{th} equation

$$F_i(w;\ \nu,c) = \sum_{j=0}^{\infty} \frac{f_j}{j!} (\tfrac{1}{2}\text{dg}\ [\hat{\sigma}^2 s_{ii} I_T - X_i\ \text{cov}(\hat{\beta}_i)\ X_i'])^j$$

For the t^{th} observation in the i^{th} equation, the expression becomes

$$F_{it}(w;\ \nu,c) = \sum_{j=0}^{\infty} \frac{f_j}{j!} \left(\tfrac{1}{2}\left[\hat{\sigma}^2 S_{ii} - \sum_{m=1}^{k_i} \sum_{n=1}^{k_i} X_{itm} \operatorname{cov}(\hat{\beta}_i)_{mn} X_{itn}\right]\right)^j$$

where X_{itm} is the t^{th} observation on the m^{th} variable in the i^{th} equation which contains k_i explanatory variables, and $\operatorname{cov}(\hat{\beta}_i)_{mn}$ is the element in the m^{th} row and n^{th} column of $\operatorname{cov}(\hat{\beta}_i)$.

Finally, the expression $f_j/j!$ needs to be calculated. This term is independent of both the equation being considered and the time period and thus needs to be calculated only once. For simplicity, $\nu = mT - \sum_{i=1}^{m} k_i - g$ is set to the nearest lower positive, even integer to allow replacing the gamma function by factorials. The expression $f_j/j!$ is then calculated recursively for increasing values of j.

$$\frac{f_j}{j!} = \frac{(\tfrac{1}{2}\nu)^j\ (\tfrac{1}{2}\nu-1)!}{(\tfrac{1}{2}\nu+j-1)!\ j!}$$

$$= \frac{\tfrac{1}{2}\nu}{(\tfrac{1}{2}\nu+j-1)j} \cdot \frac{f_{j-1}}{(j-1)!} \qquad j = 1, 2, \ldots.$$

$f_o/0! = 1$, and $f_j/j!$ is calculated recursively for $j = 1, 2, \ldots.$

In the case of the problem in the text, convergence of $F(w;\ \nu,c)$ occured in five or six terms of the summation.

APPENDIX B

Page

Data Appendix

APPENDIX B

SOURCES AND NOTES FOR TABLES

Tables MO-1, SO-1, AO-1

Data on outputs and prices of crops and livestock have been taken from the Farm Production Index Database. It was kindly provided by the Farm Income and Prices Section, Agriculture Division at Statistics Canada. As its title indicates, the database is used in the estimation of the Index of Farm Production. It is available from 1951 to 1985. Unfortunately, the database does not extend beyond 1985 due to the termination of publication of Statistics Canada's Index of Farm Production.

Output of a farm product is assumed to include quantities sold by farmers (except direct interfarm sales within the province), amounts consumed in farm homes on farms where produced and amounts equal to the annual change in farm-held inventories of crops and livestock. This definition avoids double-counting, which would occur, for example, when feed grains credited to field crop production were fed to livestock and were counted again later as livestock production. It also avoids interprovincial duplication by adjusting provincial livestock production for feeder livestock imported from other provinces.

Tables MO-1, SO-1, and AO-1 show total output for grains, oilseeds, vegetables, and livestock products. The tables also indicate which items make up the total. Grains and oilseeds output include sales plus inventory change; for most vegetables, output is simply a measure of sales; and for eggs, wool, and honey, it is the sum of sales and home consumption. In the case of livestock, total output does not appear - only the components are shown. Livestock marketings are measured in hundredweight; while livestock inventory change and imports are measured in head. Without some assumptions about weight per head, it is not possible to show total livestock output measured in physical terms.

It will be noted that in certain years, negative observations appear for total output of oats. This follows from the fact that inventory change of oats was large and negative and exceeded commercial sales of oats. The large withdrawals from inventories moved through non commercial channels and, as such, were not recorded in the calculation of oats output. They were ultimately used as livestock feed and consequently the oats production was translated into livestock production.

Our analysis could not handle negative output. Hence, whenever negative values appeared for oats, output was assumed to equal zero and the negative value was treated as an input to livestock production. The latter appear in Tables MI-1.3, SI-1.3, and AI-1.3 under Oats Feed.

Below each measure of output, is the corresponding price of a unit of that output. The prices are transactions prices received by farmers when ownership first changes hands. They include subsidies, bonuses and premiums which can be attributed to specific commodities.

Tables MO-2, SO-2, AO-2: Outputs of grains and oilseeds, as recorded in Tables MO-1, SO-1, and AO-1, were adjusted for the effects of weather. The amount of the adjustment was determined by the application of the weather adjustment index to the physical production of grains and oilseeds. The data on physical production are not presented in Appendix B but the historical levels do appear in Handbook of Agricultural Statistics, Part 1 Field Crops, 1921-1974, catalogue no. 21-516 and more recent levels appear on CANSIM. After making the adjustment for weather, grains and oilseeds output was converted from physical units to constant dollars by multiplication by the 1981 price.

Tables MO-3, SO-3, AO-3: Aggregate crop output is the sum of weather-adjusted grain and oilseeds output of Tables MO-2, SO-2, or AO-2 and vegetable output of Tables MO-1, SO-1, or AO-1 converted to 1981 dollars.

Aggregate livestock output is the sum of all the remaining items in Tables MO-1, SO-1, or AO-1 converted to 1981 dollars.

Tables MI-1.1, SI-1.1, AI-1.1: Labour Force Survey Section of Households Survey Division at Statistics Canada provided the employment data necesssary to generate series on employment in three classes of workers - paid workers, unpaid family workers, and owner operators.

The data over 1975-1985 is exactly as they gave it to us.

The data over 1966-1974 required adjustment. Data over that period were collected acccording to old L.F.S. definitions and hence were inconsistent with the post-1975 data. Fortunately, there was one year of overlapping data, 1975, wherein employment data were available according to both old and new L.F.S. definitions. Consequently, the L.F.S. employment data over 1966-1974 in each class were scaled by the ratio of 1975 revised L.F.S. employment data in that class to 1975 old L.F.S. employment data in that class.

Data over 1961-1965 were sparse. L.F.S. was able to distinguish employment data for only two classes of workers (paid workers and others), for only the aggregate of the Prairie Provinces, and based on old definitions. The data indicated that the share of paid workers in total employment over 1961-1965 was approximately equal to the average share over 1966-1969. Hence, total L.F.S. employment in each province was adjusted to reflect new definitions (by the scaling method described above) and then apportioned to the three classes according to the average distribution over 1966-1969.

Data on total wages to paid workers are published in Agriculture Economic Statistics, Statistics Canada, catalogue no. 21-603. They appear under Farm Operating Expenses and

Depreciation Charges.

The average wage for paid workers was calculated as total wages to paid workers divided by the number of paid workers. The average wage imputed to unpaid family workers was assumed to equal 90 per cent of the paid worker average wage. Finally, the average wage imputed to owner-operators was assumed to equal 110 per cent of the provincial Industrial Composite average wage (i.e. average weekly earnings for the Industrial Composite multiplied by 52).

Tables MI-1.2 SI-1.2 AI-1.2

If fully imputed, capital costs include depreciation on buildings, depreciation on machinery, the carrying cost of land and buildings, and the carrying costs of machinery, of livestock, and of grain stocks. These tables do not present the calculated carrying costs and their accompanying price indexes, but they do provide the raw data necessary for the calculations.

Depreciation on buildings and on machinery are published in Agriculture Economic Statistics, Statistics Canada, catalogue no. 21-603, in the table on Farm Operating Expenses and Depreciation Charges.

Current value of land and buildings, machinery and equipment, and livestock are also published in Agriculture Economic Statistics, but in the table Current Values of Farm Capital. Data on the current value of the farmhouse were supplied on worksheets by the Farm Income and Prices Section of Statistics Canada. The value of grain stocks on farms were provided on worksheets by the Crops Section, Agriculture Division of Statistics Canada.

The estimate of carrying cost of land and buildings (M&E, livestock, or grain stocks) is the product of the current value of land and buildings (M&E, livestock, or grain stocks) and an interest rate. The interest rates appear on the third page of Tables MI-1.2, SI-1.2, and AI-1.2. The prime business loan rate and the Treasury Bill Rate are published in the Bank of Canada Review and are also available from CANSIM. The FCC mortgage rate was estimated on the basis of data on FCC lending rates in Farm Credit Statistics 1987, Farm Credit Corporation Canada.

The estimates of the rental rate per acre and the area of farmland are based on data supplied by Farm Income and Prices Section of Agriculture Division, Statistics Canada.

The value of land and buildings per acre, when multiplied by the appropriate interest rate, yields a price index corresponding to the carrying cost of land and buildings. The value of land and buildings per acre also came from Farm Income and Prices Section.

The Farm Input Price Index for machinery replacement, when multiplied by the prime rate, gives a price index corresponding to the carrying cost of machinery and equipment. Similarly, the Farm Input Price Index for feeder livestock when multiplied by the prime rate, gives a price index corresponding to the carrying cost of livestock. The source of FIPI's is given in the notes on Tables MI-1.3, SI-1.3, and AI-1.3.

The wheat price index, when multiplied by the prime rate, produces a price index corresponding to the carrying cost of wheat stocks. The wheat price index, along with the other crop price indexes, have been calculated from the data in Tables MO-1, SO-1, and AO-1.

Tables MI-1.3, SI-1.3, AI-1.3 Most of the data on other farm inputs are published in Agriculture Economic Statistics, Statistics Canada, catalogue no. 21-603. They appear under Farm Operating Expenses and Depreciation Charges.

The exceptions are Insurance, Fencing, Custom Work, Heating Fuel, and Miscellaneous. In the publication, they are entered as a total under the single item, Miscellaneous. The individual components were obtained from CANSIM.

Two farm inputs require particular mention. Oats Feed has a positive value in those years in which withdrawals from farm inventories of oats exceeded sales. According to our definition of output, this situation implies negative oats output. In fact, oats output is not negative - it is simply that noncommercial sales of oats for livestock feed have not been counted in output. Rather that output of oats is captured later in the measure of livestock output. Whenever oats output is calculated as being negative, it is set equal to zero and the absolute value of the negative is taken to be a livestock input in the form of Oats Feed.

The other farm input requiring a comment is Calf Imports. It appears only in the province of Alberta. Calf output is measured as the sum of marketings and inventory change less imports. In some years, this yields a negative value for calf output. The negative output was replaced by zero, and its absolute value was treated as an input under Calf Imports.

Corresponding to each of the other farm inputs, there is a Farm Input Price Index. The FIPI are published in Farm Input Price Index, Statistics Canada, catalogue no. 62-004 and are also available on CANSIM.

The FIPI are available by province only back to 1971 but are available for the West back to 1961. Hence, to obtain provincial data back to 1961, each province was extrapolated from 1971 backwards on the basis of Western FIPI growth rates.

There are several FIPI for feed. The FIPI used here was that for prepared feed. There was no FIPI corresponding to Property

Insurance and, to approximate price change for that input, we used the Home Insurance Premiums component of the Consumer Price Index. Similarly, there was no FIPI corresponding to Crop Insurance. We prepared our own price index based on data received from Agriculture Canada.

Tables MI-1.4 SI-1.4 AI-1.4 Gross Farm Rent and Interest on Indebtedness appear in Agriculture Economic Statistics, Statistics Canada, catalogue no. 21-603. They are included in the table on Operating Expenses and Depreciation Charges.

Tables MI-2.1 SI-2.1 AI-2.1 Labour Costs include wages to paid workers, imputed wages to unpaid workers, and imputed wages to owner operators. Tables MI-1.1, SI-1.1, AI-1.1 contain the raw data.

Other Costs is the sum over all other inputs in Tables MI-1.3, SI-1.3, and AI-1.3

Capital Costs include depreciation on buildings, depreciation on machinery, carrying cost of land and buildings (less 85 per cent of the value of the farmhouse), carrying cost of machinery and equipment, carrying cost of livestock and poultry, and carrying cost of grain and oilseed stocks. The carrying cost of M & E, livestock, and farm-held stocks are calculated using the prime rate. The carrying cost of land and buildings is calculated using the prime rate, the Treasury Bill Rate, the FCC Mortgage Rate, 4 %, and the Rental Rate. Hence, there appear five different estimates of Capital Costs and five different estimates of Total Costs. The raw data appear in Tables MI-1.2, SI-1.2, AI-1.2.

Tables MI-2.2 SI-2.2 AI-2.2 As the title indicates, the only imputed cost in these tables is the carrying cost of land and buildings. Labour Costs cover only wages to paid workers; Other Costs include all other inputs in Tables MI-1.3, SI-1.3, and AI-1.3; and Capital Costs include depreciation on buildings, depreciation on machinery, and the carrying cost of land and buildings (at 4 % and the rental rate).

Tables MI-2.3 SI-2.3 AI-2.3 Cash Costs include wages to paid workers, the other costs of Tables MI-1.3, SI-1.3, and AI-1.3, Gross Farm Rent and Interest on Indebtedness (in Tables MI-1.4, SI-1.4, and AI-1.4)

APPENDIX B

LIST OF TABLES - ALBERTA

Appendix B Tables - Alberta

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Appendix B Tables - Saskatchewan

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LIST OF TABLES - MANITOBA

Appendix B Tables - Manitoba

Available upon request

APPENDIX B

LIST OF CHARTS

Appendix B Charts

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List of Tables included in Appendix B.

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