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Macro-Economic Influences on Alberta Farmland Values

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Abstract

This is the first of two final reports to Farming for the Future Council exploring certain macroeconomic impacts on the Canadian agricultural sector. This first report gives the results of applying two alternative lead-lag methodologies to assess the impact of various macroeconomic variables on Alberta farmland prices. Based on these results, a structural model of the demand for and supply of farmland offered for sale is specified. In the second related report (for ARCA Project 87-0113) the OLS lead-lag methodology is also extended to assessment of the impact of macroeconomic variables on measures of farm income and results of the land price determination in the first report are derived and discussed. This final report for ARCA 85-0539 and that for ARCA 87-0113 are, therefore, highly complementary.

The findings from this first report indicate that a number of macroeconomic and related variables do influence nominal land values. These include interest rates (particularly the real long-run interest rate), the general economy-wide price level, aggregate income levels (GDP) and the U.S.-Canadian dollar exchange rate. Amongst the various variables reflecting returns from farming, realized net farm income, the prices of farm outputs, inputs, and the terms of trade appear to particularly influence farmland values. We conclude that monetary policy, in particular, the levels of real long-run interest rates, strongly affects Alberta farmland values.

I. Introduction

During the past two decades, Canadian agriculture has been increasingly affected by national and international economic influences and policies. Canadian and Alberta farmers' asset values, indebtedness, cash flow, and economic situation are increasingly subject to the influence of macroeconomic pressures which are exogenous to the agricultural sector. Land values, in particular, appear to be highly influenced by such forces and have shown much variation. Following a period of relative stability in land prices during the 1950s and 1960s, there was rapid escalation in both nominal and real values of farmland from 1973 until 1976 and also from 1978 to 1980. Since 1981, when Canadian farmland values peaked, these values have fallen in both nominal and real terms. There is increasing recognition that macroeconomic forces have influenced these and other facets of the economic environment of the agricultural sector but little research has been done to date to delineate these effects. The purpose of this study is to investigate the impact of selected macroeconomic influences on this important facet of farmers' economic situation.

A. Objectives

The objectives of this study are to investigate the effects on farmland values of major economic influences, specifically: 1) to investigate the impacts of measures of farming returns and monetary variables on farmland values; and 2) to assess the impact of national monetary policy on farmland values over the past two decades.

B. Approach

The relationships between Alberta farmland values and the factors influencing these values are determined by applying lead-lag analysis to assess the individual impact, in terms of Granger causality, of various measures of the factors that economic theory and previous evidence indicate to be determinants of farmland values. A time series variable, x, is said to "lead" another time series variable, y, if current values of y can be predicted better by using the history of x than without, with all other information being used in either case. The concept of causality involved in this approach thus relates to statistical rather than behavioural relationships. The approach has been used here to assess whether there are lead-lag macroeconomic and related relationships between variables suggested by theory (and other evidence) on land values and to assess whether particular measures of alternative macroeconomic indicators appear to have the stronger lead-lag relationships with land values than other measures of the same indicator. The results from the application of lead-lag analysis are used to suggest particular measures of macroeconomic or aggregate economic influences on Alberta farm land values in a postulated behavioural model of supply and demand for Alberta farmland. This is outlined in an Appendix to this report. A subsequent related study (ARCA 87-0113) provides further testing of this model. The general methodological approach applied here has been widely used in recent years but its limitation of being statistically rather than behaviourally based must be recognized.

II. Methodology

A. Choice of Variables, Variable Description, and Data Sources

Economic theory and previous studies suggest a number of economic influences and particular variables that may influence current values of farmland. The revenue generating aspects of farmland are well recognized as being important factors in determining farmland values. Returns to farmland include income from the production and sale of farm products as well as changes in the value of farming assets. Thus variables or measures that relate to farm returns and changes in capital values from farming are included. In addition, we are interested in the impact of various macroeconomic variables on farmland values. These variables may influence the farmland market either directly (through their impact on farmland buyers or sellers' valuations or perceptions of the worth of this asset) or indirectly (e.g., by influencing revenue generating aspects of farmland). We expect that interest rates may affect farmland values directly (adversely affecting the costs of farm debtors and the levels of net farm income) as well as indirectly (through their influence on the national level of income and employment and through their relationships with exchange rates). Because a variety of different interest rates apply at any one time, several interest rate measures are considered in this study. We expect that exchange rates may influence demand for agricultural exports, and that such affects on traded volumes or prices may affect the levels of gross and net farm income. We include a measure of money supply; this variable is expected to influence the level of farmland values indirectly, through the influences of interest rates and exchange rates. We also evaluate the impact of a number of Alberta-based prices, as measured by specific indices of price changes in the general economy and the agricultural economy.

Altogether, six groups of variables, totalling 33 variables in all, are examined for their influence on Alberta farmland value. The study applies annual data for the time period 1961-1984. The following is a list of the names of the variables considered and an outline of the source of each data series.

1. Value per acre of farmland and buildings [V]

2. 1) Exchange rate [EX]
   2) Money supply (currency in circulation and demand deposits at chartered banks) [M]
   3) Short term nominal interest rate [SR]
   4) Long term nominal interest rate [LR]
   5) Rate of inflation based on percentage change in consumer price index (CPI Canada) [PI1]
   6) Rate of inflation based on the implicit price index, (IMP, Canada) [PI2]
   7) Short term real interest rate I [RSR1] (using CPI)
   8) Short term real interest rate II [RSR2] (using IMP)
   9) Long term real interest rate I [RLR1] (using CPI)
   10) Long term real interest rate II [RLR2] (using IMP)
   11) Consumer price index (Alberta) [CPI]
   12) Implicit price index (Alberta) [IPI]

3. 1) Farm output price index (Western Canada) [FOP]
   2) Farm input price index (Western Canada) [FPI]
   3) Agricultural terms of trade (Western Canada) [TT]
   4) Total gross farm income (Alberta) [TG]
   5) Total net farm income (Alberta) [TN]
   6) Realized gross farm income (Alberta) [RG]
   7) Realized net farm income (Alberta) [RN]
   8) Farm cash receipts (Alberta) [C]
   9) Interest on indebtedness (Alberta) [CR]
   10) Gross farm rent (Alberta) [RT]
   11) Farm operating expenditures (Alberta) [OE]
   12) Farm taxes (Alberta) [CT]

13) Farm mortgage price index (Western Canada) [MG]

The variable V is Statistics Canada's census-reconciled value per acre of farmland and buildings for the province of Alberta. This is an average value of all farmland including pasture and unimproved farm lands.

The exchange rate variable is included in the set of possible determinants of farmland values because of the importance of foreign trade to the agricultural sector. The variable EX is defined to be the price of a US dollar in terms of Canadian dollars. These data were from Canada Department of Finance, *Economic Review, Annual*, various issues.

In order to capture the effects of national monetary policy, a number of monetary variables are considered. In addition to a measure of the national money supply and measures of the rate of inflation, short-term and long-term nominal and real interest rates are also examined. The variable M denotes the money supply applying the M_1 or narrow money definition which includes currency in circulation and demand deposits at chartered banks. The inflation rate variables PI1 and PI2 are the reported annual percentage changes of the consumer price index (CPI) and implicit price index (IMP) respectively. The source of these price data are International Monetary Fund, *International Financial Statistics*. The base year for the calculation of PI1 is 1981 whereas the base year for PI2 is 1971. The short-and long-term interest rates (SR and LR) are defined to be the rate of return on 3 month treasury bills and long-term government bonds respectively. Using the two different inflation rates, PI1 and PI2, different short and long-term real interest rates are defined as follows:

Short-term real interest rate I, termed RSR1 = SR - PI1

Short-term real interest rate II, termed RSR2 = SR - PI2

Long-term real interest rate I, termed RLR1 = LR - PI1

Long-term real interest rate II, termed RLR2 = LR - PI2

To examine the impact of price relationships between the agricultural sector and the rest of the economy, the Alberta farm output price index [FOP] and the Alberta farm input price index [2] [PFI] are considered as is the terms of trade for agriculture in Alberta [TT]. This variable

[2] These indexes are from Statistics Canada, 62-003.

is defined as (FOP/FPI)100.

The revenue generating aspects of farmland are well recognized as being an important factor in determining farmland values. Thus, a number of Alberta farm revenue and farming cost variables[3] are included in the analysis. Total gross income [TG], total net income [TN], realized net income [RN] and farm cash receipts [C] are the selected revenue variables. The chosen cost variables are interest on indebtedness [CR], gross farm rent [RT], operating expenditures [OE], taxes [CT], and mortgage price index [MG].

It is also possible that the overall performance of the economy will exert a macro-influence on farmland values. To explore this, the existence of lead-lag relationships between farmland values and the variables nominal GDP of Alberta [MY], per capita nominal GDP of Alberta [PCMY], real GDP of Alberta [CY] and per capita real GDP of Alberta [PCCY] are also studied.[4]

Variables representing general price levels in Alberta, represented by the Alberta-level consumer price index[5] [ACP1] and implicit price index[6] [A1MP] were also used in deflating these series. The base years of these price indices were 1981 and 1971, respectively. For the subsequent analysis all price indexes were converted to a base of 1981=100.

Finally, capital gain variables are also included in recognition of the fact that total returns to farmland owners come, in part, from changes in the value of this asset. Nominal capital gain [DV], real capital gain I [RDV1], real capital gain II [RDV2] and real expected capital gain [RECG] are the capital gain variables studied. These variables are defined as follows.

Nominal capital gain, termed $DV(t) = V(t) - V(t-1)$,

Real capital gain I, termed $RDV1 = DV/ACPI(t)$

Real capital gain II, termed $RDV2 = DV/AIMP(t)$ and

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[3] The data series on these variables are from Agricultural Canada, *Handbook of Selected Agricultural Statistics*.

[4] The data series on MY, CY, and PCMY were obtained from *Economic Review*, Department of Finance, Canada, and *Alberta Economic Accounts*, Alberta Treasury, Bureau of Statistics. PCCY was derived by dividing CY by the population of Alberta. Data on Alberta population levels were obtained from Statistics Canada, 91-201.

[5] The CPI data series are from Statistics Canada, 62-001.

[6] The data on Alberta Implicit Price Index are from *Alberta Economic Accounts*.

Real expected capital gain, termed RECG(t) = {1/6[V(t-2)-V(t-3)] + 1/3[V(t-1)-V(t-2)] + 1/2[V(t)-V(t-1)]} AIMP(t).

B. Methodological Approach

Granger's approach permits eight possible lead-lag relationships in a bivariate system of x and y, namely:

1. $x \rightarrow y$ [x leads y]
2. $y \rightarrow x$ [y leads x]
3. $x \leftrightarrow y$ [instantaneous relationship]
4. x - y [statistical independence]
5. $x \rightarrow y$, $y \rightarrow x$ [feedback]
6. $x \rightarrow y$, $x \leftrightarrow y$ [x leads y only and instantaneous relationship exists]
7. $y \rightarrow x$, $x \leftrightarrow y$ [y leads x only and instantaneous relationship exists]
8. $x \rightarrow y$, $y \rightarrow x$, $x \longleftrightarrow y$ [feedback and instantaneous relationship exists]

A variety of causality tests are available to study the existence of lead-lag relationships between variables. Geweke, Meese and Dent provide a review of these. The two widely used methods are the ordinary least squares version of the Granger test and residual cross-correlation analysis. Both methods were used in this initial study.

C. The Ordinary Least Squares Technique

This technique, suggested by Geweke and widely applied since then (see, for example, Adamowicz, Baah and Hawkins, Bessler and Brandt, Garcia, Leuthold and Zapata, and Sims), estimates and compares the restricted and unrestricted time series models using ordinary least squares.

To test for $x \rightarrow y$ the following models are estimated:

Model A: $$y_t = a_0 + \sum_{i=1}^{k} a_i y_{t-i} + e_{at}$$

Model B: $$y_t = b_0 + \sum_{i=1}^{k} b_i y_{t-i} + \sum_{j=1}^{m} d_j x_{t-j} + e_{bt}$$

where k and m are chosen so as to whiten the time series of y and x. Then, to test for $x \rightarrow y$, the null hypothesis $d_j=0$, $j=1,2...m$ is tested using the F-statistic:

$$F_{ab} = [(SSE_a - SSE_b)/m] / [SSE_b/(T-k-m-1)]$$

where SSE refers to the sum of squared residuals and T is the number of observations. Under the null hypothesis, F_{ab} is distributed as F with (m, T-k-m-1) degrees of freedom.

To test whether an instantaneous relationship applies, model C is compared with model B.

$$\text{Model C: } y_t = c_0 + \sum_{i=1}^{k} c_i y_{t-i} + \sum_{j=0}^{m} d_j x_{t-j} + e_{ct}$$

The test of no instantaneous relationship is carried out by testing the null hypothesis that $d_0 = 0$ using the F-statistic:

$$F_{bc} = [(SSE_b - SSE_c)] / [SSE_c/(T-k-m-2)]$$

which is again distributed as F with degrees of freedom 1 and T-k-m-2.

The power of the F-tests depends on the degree of auto-correlation present in the models. This can be diagnosed by applying the Ljung-Box diagnostic test based on the statistic:

$$Q = T(T+2) \sum_{n=1}^{L} (T-n)^{-1}) r^2_n$$

where r_n is the kth residual auto-correlation and L can be any number beyond which auto-correlation is expected to be random; Q is asymptotically distributed as chi-squared with (L-n) degrees of freedom under the null hypothesis that no auto-correlation is present in the model.

D. **The Residual Cross-Correlation Analysis Technique**

The first step in this method is to identify and estimate an appropriate time-series model. A time series will be generated by an autoregressive moving average or an autoregressive integrated moving average process, which may be expressed, respectively, as:

$$F(B)x_t = u_t$$

$$x_t = G(B)u_t$$

$$F(B)x_t = G(B)u_t \text{ or}$$

$$F(B)(1-B)^d x_t = G(B)u_t$$

where u_t is white noise, F(B) and G(B) are polynomial functions of B (infinite polynomials) and B is a backshift operator defined by $B_k x_t = x_{t-k}$

Let v_t be the white noise of an appropriate time series model of y_t. Then the theoretical cross-correlation between u_t and v_t at lag k is defined as:

$$\rho_{uv}(k) = \frac{E[u_{t-k}, v_t]}{\{E[u_t^2]\, E[v_t^2]\}^{1/2}}$$

Cross-correlations ρ_{uv} can be used to determine lead-lag relationships between variables. Various patterns of cross-correlation imply various types of lead-lag relationships as outlined below.

1. If $\rho_{uv}(k) \neq 0$ for some $k > 0$, then $x \rightarrow y$
2. If $\rho_{uv}(k) \neq 0$ for some $k < 0$, then $y \rightarrow x$
3. If $\rho_{uv}(k) \neq 0$ for $k = 0$, then $x \leftrightarrow y$
4. If $\rho_{uv}(k) \neq 0$ for some $k > 0$ and for some $k < 0$, then $x \rightarrow y$, and $y \rightarrow x$
5. If $\rho_{uv}(k) \neq 0$ for some $k > 0$ and $k = 0$, then $x \rightarrow y$, and $x \leftrightarrow y$
6. If $\rho_{uv}(k) \neq 0$ for some $k < 0$ and $k = 0$, then $y \rightarrow x$, and $x \leftrightarrow y$
7. If $\rho_{uv}(k) \neq 0$ for some $k > 0$ and $k = 0$, then $x \rightarrow y$, and $x \leftrightarrow y$
8. If $\rho_{uv}(k) \neq 0$ for all k, then x and y are independent.

The error terms u_t and v_t of the equations above are not observable. Thus, they are estimated by u_t and v_t using Box-Jenkins univariate time series modelling techniques. Then an estimate of $\rho_{uv}(k)$, say $r_{uv}(k)$ at lag k, is specified as:

$$r_{uv}(k) = \frac{\Sigma u_{t-k}.v_t}{\{\Sigma u_t^2.\Sigma v_t^2\}^{1/2}}$$

The Box-Jenkins technique is based on the fact that most time series can be adequately represented by a finite number of autoregressive and/or moving average terms. If the series is already stationary, then the model is said to be an autoregressive-moving average (ARMA) model of order (p, q). If d differences of the original series are required to obtain stationarity, the resultant model is known as an autoregressive integrated moving average (ARIMA) model of order (p, d, q) where p = the number of autoregressive terms, and q = the number of moving average terms in the model.

The steps involved in the application of the Box-Jenkins technique are as follows:

1. Check the series for stationarity. If the series is non-stationary, remove the non-stationarity by differencing or taking logarithms.
2. Examine the auto-correlation functions (ACF) and partial auto-correlation functions (PACF) and from their distributions determine the autoregressive and moving average structure.
3. Estimate the model.
4. Examine the ACF and PACF of the estimates of the residuals and perform the Ljung-Box diagnostic Q-test (to determine whether the residuals are white noise) where:

$$Q = T(T+2) \sum_{k=1}^{L} (T-k)^{-1} r^2_k$$

Q is asymptotically distributed as chi-squared with (L-p-q) degrees of freedom. If the residuals do not represent white noise, the model is modified and re-estimated. This procedure is continued until a white noise series is evident for the residuals.

Pierce and Miller have suggested a procedure to use U-statistics to test for significant lead-lag relationships. The relevant U-statistics are

$$U_0 = T \sum_{k=1}^{L} [r_{uv}]^2$$

$$U_1 = T \sum_{k=-1}^{-L} [r_{uv}]^2 \quad \text{and}$$

$$U_2 = T \sum_{k=-L}^{L} [r_{uv}]^2$$

where T is the number of observations and k is the number of lags such that $-L \leq k \leq L$.

U_0 tests the null hypothesis that x_t does not lead y_t, while

U_1 tests the null hypothesis that y_t does not lead x_t, and

U_2 tests the independence of x_t and y_t.

Under the null hypotheses, U_0, U_1 and U_2 are distributed asymptotically as chi-squared with degrees of freedom L, L and 2L+1 respectively.

III. The Procedures and Results

A. OLS Technique

The data series of all the relevant variables were first whitened. To do this, each variable was individually regressed on a successively increasing number of lags of its own value until the resulting series was completely whitened. The Ljung-Box Q-test was used as the criterion to determine the number of lags to be included in each case. For example, the per acre land value V_t was regressed on V_{t-1} and the Q-test was carried out. If this indicated that it was still to be whitened, V_t was regressed on V_{t-1} and V_{t-2} and the Q-test was again carried out. This iterative procedure was continued until the Q-statistic showed that the residuals were white noise. Using this procedure, the residuals of data series of all the relevant variables were whitened. The Q-test indicated that the data series were to be regressed on six of these lags to be whitened completely.

Secondly, taking y as the objective variable of land value per acre in Alberta and x as the various hypothesized land values, each at a time, models A, B and C were estimated using the OLS technique. The computer program Shazam (version 5.0) was used to estimate all models. F-tests were then carried out to test for lead-lag and instantaneous relationships between per acre land values and each of the determinants. Since the power of the F-tests depends on the degree of auto-correlation present in the models, the Ljung-Box diagnostic test was carried out to test for auto-correlation.

Table 1 gives the F-statistics for testing one way causality of the variables considered with land values from comparing Model A with Model B. Table 1 also gives the F-statistics for testing contemporaneous causality (i.e. comparing and Model B with Model C) for all the determinants considered in the study. These F-statistics provide the basis for conclusions given in Table 2 regarding the lead-lag relationships between values of farm land per acre (y) and the possible determinants (x) considered. The detailed results of the various equations underlying Tables 1 and 2 are given in Appendix Tables 1 and 2.

B. Residual Cross Correlation Analysis

As a means of assessing the lead-lag relationships between the Alberta farmland values and possible determinants, residual cross correlation analysis using the Box-Jenkins technique was also applied in this study.

In order to check for stationarity of the data series, each series was plotted against time (expressed in years). Whenever a series exhibited a systematic trend, it was differenced consecutively until it became stationary. In most cases, the data were differenced twice. However, the data series on the nominal short term interest rate, inflation rate I, inflation rate II, real short term interest rate I, total gross income, interest on indebtedness, farm input price index, farm output price index, terms of trade and real expected capital gain were differenced only once and the data series on cash receipts had to be differenced three times to be made stationary. The auto-correlation functions (ACF) and partial auto-correlation functions (PACF) of these stationary series were then plotted and from the resulting distributions, the order of the

Table 1: One Way and Instantaneous Causality Tests Using OLS

Variables		One Way Causality Tests Comparing Model A with Model B F-statistics[1]	Instantaneous Causality Tests Comparing Model B with Model C F-statistics[2]
A.	1. Exchange rate	**6.08	0.18
	2. Money supply (M)	2.09	0.97
	3. Consumer price index (CPI)	**153.20	3.19
	4. Implicit price index (IMP)	**46.33	7.07
	5. Inflation rate I (using CPI)	**9.03	6.71
	6. Inflation rate II (using IMP)	**7.51	5.76
	7. Short-term nominal interest rate	1.68	0.25
	8. Short-term real interest rate I (using CPI)	3.74	0.07
	9. Short-term real interest rate II (using IMP)	3.96	0.10
	10. Long-term nominal interest rate	3.67	0.08
	11. Long-term real interest rate I (using CPI)	**6.67	**14.23
	12. Long-term real interest rate II (using IMP)	**5.96	**18.05
	13. Nominal GDP (Alberta)	**26.99	0.33
	14. Per capita nominal GDP	**6.47	0.09
	15. Real GDP	**9.61	0.11
	16. Per capita real GDP	**10.64	0.37
B.	1. Farm output price index	**153.79	2.79
	2. Farm input price index	**71.60	**11.56
	3. Terms of trade	3.01	2.29
C.	1. Cash receipts	**12.54	5.35
	2. Realized gross income	**14.24	0.32
	3. Realized net income	**6.84	**10.32
	4. Total gross income	**43.99	1.49
	5. Total net income	**15.17	3.01
	6. Interest on indebtedness	**10.79	1.96
	7. Rent paid	2.28	**89.38
	8. Mortgage price index	*11.63	2.23
	9. Tax paid	**7.62	0.05
	10. Operating expenditures	2.47	**22.19
D.	1. Nominal capital gain (V_t-V_{t-1})	0.50	**256,638.10
	2. Real capital gain I (using CPI)	1.75	**92.15
	3. Real capital gain II (using IMP)	0.35	**98.15
	4. Real expected capital gain	**210.95	6.83

[1] F-test H_0: The impact of independent variables as a group is equal to zero; F* 0.05 = 4.95.

[2] F-test H_0: Non-existence of instantaneous causality between the two time series; F* 0.05 = 7.71.

** Denotes that the test statistic is significant at the 95 percent level.

Table 2: Lead-Lag Relationships for Alberta Farm Land Value and Associated Variables

Variable x			Apparent Relationship of Variables x with Land Values
A.	1.	Exchange rate	x → y
B.	2.	Money supply	
	3.	CPI	x → y
	4.	Implicit price index	x → y,
	5.	Inflation rate I	x → y
	6.	Inflation rate II	x → y
	7.	Short-term nominal interest rate	
	8.	Short-term real interest rate I	
	9.	Short-term real interest rate II	
	10.	Long-term nominal interest rate	
	11.	Long-term real interest rate I	x → y; x ↔ y
	12.	Long-term real interest rate II	x → y, x ↔ y
	13.	Nominal GDP (Alberta)	x → y
	14.	Per capita nominal GDP	x → y
	15.	Real GDP	x → y
	16.	Per capita real GDP	x → y
B.	1.	Farm output price index	x → y
	2.	Farm input price index	x → y; x ↔ y
	3.	Agricultural terms of trade	x → y; x ↔ y
C.	1.	Cash receipts	x → y
	2.	Realized gross income	x → y
	3.	Realized net income	x → y, x ↔ y
	4.	Total gross income	x → y
	5.	Total net income	x → y
	6.	Interest on indebtedness	x → y
	7.	Gross farm rent	x ↔ y
	8.	Mortgage price index	x → y
	9.	Taxes	x → y
	10.	Operating expenditures	x ↔ y
D.	1.	Nominal capital gain	x ↔ y
	2.	Real capital gain I	x ↔ y
	3.	Real capital gain II	x ↔ y
	4.	Real expected capital gain	x → y

autoregressive and moving average structure of each of the series was determined. Once the time series structures were determined, the appropriate ARIMA models were estimated. All these procedures were done using the MINITAB statistical computer package. The Ljung-Box diagnostic Q-test was carried out in each case to test for the randomness of the residuals. In cases where the Q-test indicated that the residuals were not yet white noise, the ACFs and PACFs of the residuals were examined and the models were modified and re-estimated appropriately.

The cross-correlations between the residuals of the ARIMA model of per acre land value and 13 different lags (including 6 backward lags and 6 forward lags) of the residuals of the ARIMA models of each of the possible determinants were calculated. Using the cross-correlations, U_0, U_1, and U_2 statistics were calculated to test for significant lead-lag relationships. These are summarized in Table 3. The estimates of the ARIMA structure are in Appendix Table 3. Supplementary t-tests were applied to test the significance of the individual cross-correlations between the residuals of land values and the lagged values of residuals of the other variables. These and the U tests of Table 3 are the basis of the conclusions about the causality relationships from this method that are given in Table 4.

C. Limitations of the Analysis

The lead-lag analysis employed in this study provides only a statistical basis, rather than a behavioural basis, for interpreting causal relationships between variables. Nonetheless, when used in conjunction with available economic theory and related information, the technique is useful in substantiating and identifying the nature of statistical linkages between variables. For example, it is useful in suggesting whether alternative measures of a theoretically justifiable variable (such as interest rates or general price levels) shows a strong association with the variable under study (nominal land values in this application) or whether particular proxy variables (such as farm product prices or net farm income) can be used to assess the impact on farmland values of the theoretically justifiable but difficult to measure concept of farming profitability. A further limitation of the technique arises from the nature of the data under analysis. Since these are annual data, the number of observations for statistical analysis and the

Table 2: Lead-Lag Relationships for Alberta Farm Land Value and Associated Variables

		Variable x	Apparent Relationship of Variables x with Land Values
A.	1.	Exchange rate	x → y
B.	2.	Money supply	
	3.	CPI	x → y
	4.	Implicit price index	x → y,
	5.	Inflation rate I	x → y
	6.	Inflation rate II	x → y
	7.	Short-term nominal interest rate	
	8.	Short-term real interest rate I	
	9.	Short-term real interest rate II	
	10.	Long-term nominal interest rate	
	11.	Long-term real interest rate I	x → y; x ↔ y
	12.	Long-term real interest rate II	x → y, x ↔ y
	13.	Nominal GDP (Alberta)	x → y
	14.	Per capita nominal GDP	x → y
	15.	Real GDP	x → y
	16.	Per capita real GDP	x → y
B.	1.	Farm output price index	x → y
	2.	Farm input price index	x → y; x ↔ y
	3.	Agricultural terms of trade	x → y; x ↔ y
C.	1.	Cash receipts	x → y
	2.	Realized gross income	x → y
	3.	Realized net income	x → y, x ↔ y
	4.	Total gross income	x → y
	5.	Total net income	x → y
	6.	Interest on indebtedness	x → y
	7.	Gross farm rent	x ↔ y
	8.	Mortgage price index	x → y
	9.	Taxes	x → y
	10.	Operating expenditures	x ↔ y
D.	1.	Nominal capital gain	x ↔ y
	2.	Real capital gain I	x ↔ y
	3.	Real capital gain II	x ↔ y
	4.	Real expected capital gain	x → y

autoregressive and moving average structure of each of the series was determined. Once the time series structures were determined, the appropriate ARIMA models were estimated. All these procedures were done using the MINITAB statistical computer package. The Ljung-Box diagnostic Q-test was carried out in each case to test for the randomness of the residuals. In cases where the Q-test indicated that the residuals were not yet white noise, the ACFs and PACFs of the residuals were examined and the models were modified and re-estimated appropriately.

The cross-correlations between the residuals of the ARIMA model of per acre land value and 13 different lags (including 6 backward lags and 6 forward lags) of the residuals of the ARIMA models of each of the possible determinants were calculated. Using the cross-correlations, U_0, U_1, and U_2 statistics were calculated to test for significant lead-lag relationships. These are summarized in Table 3. The estimates of the ARIMA structure are in Appendix Table 3. Supplementary t-tests were applied to test the significance of the individual cross-correlations between the residuals of land values and the lagged values of residuals of the other variables. These and the U tests of Table 3 are the basis of the conclusions about the causality relationships from this method that are given in Table 4.

C. Limitations of the Analysis

The lead-lag analysis employed in this study provides only a statistical basis, rather than a behavioural basis, for interpreting causal relationships between variables. Nonetheless, when used in conjunction with available economic theory and related information, the technique is useful in substantiating and identifying the nature of statistical linkages between variables. For example, it is useful in suggesting whether alternative measures of a theoretically justifiable variable (such as interest rates or general price levels) shows a strong association with the variable under study (nominal land values in this application) or whether particular proxy variables (such as farm product prices or net farm income) can be used to assess the impact on farmland values of the theoretically justifiable but difficult to measure concept of farming profitability. A further limitation of the technique arises from the nature of the data under analysis. Since these are annual data, the number of observations for statistical analysis and the

Table 3: Application of U Statistics to ARIMA Estimates

Variable			U_0	U_1	U_2
A.	1.	Exchange rate	*12.34	5.12	16.88
	2.	Money supply	3.42	1.37	16.98
	3.	CPI	2.74	0.59	17.15
	4.	Implicit price index	**12.81	0.06	*20.47
	5.	Inflation rate I	9.31	1.22	*19.95
	6.	Inflation rate II	7.64	1.43	*21.19
	7.	Nominal short-term interest rate	4.12	2.16	15.39
	8.	Real short-term interest rate I	8.92	0.88	*20.29
	9.	Real short-term interest rate II	5.73	2.15	*20.55
	10.	Nominal long-term interest rate	4.48	2.19	18.18
	11.	Real long-term interest rate I	7.17	0.03	19.04
	12.	Real long-term interest rate II	*10.72	5.33	16.86
	13.	Nominal GDP (Alta)	**15.10	1.44	*21.42
	14.	Per capita nominal GDP	6.81	0.17	17.76
	15.	Real GDP	6.09	1.88	19.67
	16.	Per capita real GDP	5.28	2.18	*20.57
B.	1.	Farm output price index	**15.68	2.77	18.86
	2.	Farm input price index	**15.90	3.02	18.28
	3.	Terms of trade	*11.91	0.27	12.99
C.	1.	Cash receipts	6.75	1.03	**22.37
	2.	Realized gross income	2.84	0.01	*21.47
	3.	Realized net income	*11.78	0.45	18.27
	4.	Total gross income	8.63	4.27	13.85
	5.	Total net income	*12.44	1.77	15.62
	6.	Interest on indebtedness	9.61	3.60	*21.44
	7.	Rent paid	9.32	0.19	19.80
	8.	Mortgage price index	*10.55	3.33	17.41
	9.	Taxes paid	7.91	0.004	*19.97
	10.	Operating expenditures	1.33	0.01	13.87
D.	1.	Nominal capital gain	1.01	0.13	**24.79
	2.	Real capital gain I	2.61	0.00	*20.30
	3.	Real capital gain II	1.78	0.01	18.99
	4.	Real expected capital gain	0.86	0.02	*20.15

Notes:
* denotes that the test statistic is significant at 10%.
** denotes that the test statistic is significant at 5%.
U_0: this U statistic tests the null hypothesis that X_t does not lead V_t; χ^2 0.05 = 12.59.
U_1: this U statistic tests the null hypothesis that V_t does not lead X_t; χ^2 0.05 = 12.59.
U_2: this U statistic tests the independence of X_t and V_t, where X_t denotes the various macroeconomic and related variables considered in the study and V_t denotes land values; χ^2 0.05 = 22.36.

Table 4: Predictive Relations Based on U Statistics Applied to ARIMA Estimates

Variable x		Causality Relationship With Farm Land Value (y)
A. 1.	Exchange rate	x → y
2.	Money supply	independence
3.	CPI	independence
4.	Implicit price index	x → y
5.	Inflation rate I	undetermined
6.	Inflation rate II	undetermined
7.	Nominal short-term interest rate	independence
8.	Real short-term interest rate I	undetermined
9.	Real short-term interest rate II	undetermined
10.	Nominal long-term interest rate	independence
11.	Real long-term interest rate I	independence
12.	Real long-term interest rate II	x → y
13.	Nominal GDP (Alberta)	x → y
14.	Per capita nominal GDP	independence
15.	Real GDP	undetermined
16.	Per capita real GDP	undetermined
B. 1.	Farm output price index	x → y
2.	Farm input price index	x → y
3.	Terms of trade	x → y
C. 1.	Cash receipts	undetermined
2.	Realized gross income	undetermined
3.	Realized net income	x → y
4.	Total gross income	independence
5.	Total net income	x → y
6.	Interest on indebtedness	undetermined
7.	Gross farm rent	undetermined
8.	Mortgage price index	x → y
9.	Taxes paid	undetermined
10.	Operating expenditures	independence
D. 1.	Nominal capital gain	x ↔ y
2.	Real capital gain I	x ↔ y
3.	Real capital gain II	independence
4.	Expected real capital gain	x ↔ y

resultant degrees of freedom are relatively low. Thus the critical values appropriate to the various tests are relatively high, possibly contributing to a lack of identification of behaviourally based relationships.

IV. Discussion of Results and Conclusions

The OLS technique indicates statistical relationships in which changes in a number of macroeconomic variables statistically lead changes in nominal land values. The variables which appear to influence Alberta land values are exchange rates, measures of output prices in the general economy and measures of the rate of change of these prices, long-term real interest rates, and provincial income (GDP) levels. Since land values are considered in nominal terms in this initial study, and the time period of data observations is yearly, these features may explain the lack of apparent relationships of the nominal and short-run interest rate variables with farmland values. Of the variables that reflect returns to farming, cash receipts, gross income, net income, mortgage prices, interest costs and taxes, influence farmland prices as do farm output and input prices and the resulting terms of trade. Not surprisingly, there is also evidence of interelationships of various capital gains measures with farmland prices. The application of the residual cross-correlation technique leads to the conclusions that the exchange rate, implicit price index, real long-term interest rate (deflated by the implicit price index) and nominal aggregate Alberta GDP all influence nominal Alberta land values to some degree, as also do realized net and total net farm income, mortgage prices, farm input and output prices and agricultural terms of trade. Combining the information on the lead-lag relationships revealed by both the OLS technique and residual cross-correlation analysis results in the following conclusions.

1. Exchange rates appear to influence land values.
2. Among the macro economic monetary factors, the implicit price index and the real long-term interest rate (based on the implicit price index) appear to exert a strong influence on land values.
3. Levels of nominal GDP appear to have had an effect on nominal land values.
4. Among the various variables reflecting returns to land, realized net income appears to be an

important determinant of land value.

5. The farm output price index, farm input price index, and the agricultural terms of trade affect land values.
6. The relationship between capital gains and land values appears to be mainly instantaneous, i.e. to occur within one year. However, it is possible to conclude from the OLS technique that the expected capital gain appears to lead land values, that is, land values follow, and thus appear to be influenced by, the measure of expected capital gains.

We conclude that monetary policy, as effected through long-run interest rates, is of particular importance in influencing the levels of nominal Alberta farmland values, as are U.S.-Canadian exchange rates and the levels of prices in the economy.

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Appendix Tables 1 to 3:

The variables in these tables are defined as follows:

V - per acre value of agricultural land and buildings

EX - exchange rate

M - money supply M_1

SR - short term nominal interest rate

LR - long term nominal interest rate

PI1 - percentage change of CPI

PI2 - percentage change of implicit price index

RSR1 - short term real interest rate 1 (using CPI)

RSR2 - short term real interest rate 2 (using IPI)

RLR1 - long term real interest rate 1 (using CPI)

RLR2 - long term real interest rate 2 (using PIP)

C - cash receipts

RG - realized gross income

RN - realized net income

TG - total gross income

TN - total net income

CR - interest on indebtedness

RT - gross farm rent

OE - operating expenditure

CT - taxes

MG - mortgage price index

CPI - consumer price index

FPI - farm input price index

IPI - implicit price index

MY - Alberta GDP (nominal values)

PCMY - Alberta per capita GDP (market price)

CY - Alberta GDP (real values)

PCCY - Alberta per capita GDP (real price)

FOP - Alberta farm output price index

DV - capital gain

RDV1 - real capital gain 1 (using CPI)

RDV2 - real capital gain 2 (using IMP)

TT - Terms of trade of agriculture sector (FOP/FPI)

RECG - real expected capital gain

Fuller definitions of these variables are in the text.

Appendix 1: Regression Results

Appendix Table 1: Regression Results for Testing Bivariate Causality: One Way Causality

Variables[1]	b_0	b_1	b_2	b_3	b_4	b_5	b_6	d_1	d_2	d_3	d_4	d_5	d_6	R^2
							Estimated coefficients and t-statistics[2]							
EX→V	505.9	1.866	-1.817	0.865	-0.536	0.775	0.223	350.42	-162.3	-512.3	509.6	-539.6	-120.63	0.997
	(1.571)	(3.984)	(-2.438)	(0.876)	(-0.662)	(1.243)	(0.148)	(2.287)	(-0.714)	(-2.304)	(1.679)	(-1.082)	(-0.584)	
M→V	-108.68	1.929	-1.606	1.005	-0.143	-0.592	-1.386	0.024	-0.029	-0.013	0.0064	-0.013	0.055	0.992
	(-1.309)	(4.150)	(-2.229)	(1.057)	(-0.162)	(-0.557)	(-1.239)	(1.037)	(-1.072)	(-0.452)	(0.214)	(-0.514)	(1.847)	
SR→V	20.952	2.038	-0.877	0.951	-0.345	0.375	-2.8003	2.682	-10.507	1.156	2.763	3.187	13.651	0.99
	(0.347)	(5.969)	(-1.012)	(0.902)	(-0.283)	(0.302)	(-2.184)	(0.408)	(-1.605)	(0.150)	(0.332)	(0.433)	(1.797)	
LR→V	-98.322	1.458	-0.244	0.097	0.335	0.855	-2.691	5.094	2.291	-13.527	7.922	18.82	7.444	0.995
	(-1.9227)	(5.297)	(-0.409)	(-0.154)	(0.369)	(0.707)	(-2.789)	(0.647)	(0.278)	(-1.645)	(0.846)	(1.739)	(0.749)	
RSR_1→V	29.625	1.598	-1.123	0.181	-0.491	1.213	-0.012	0.052	-4.693	6.831	-5.925	-11.841	-2.296	0.995
	(1.373)	(3.265)	(-1.276)	(0.161)	(-0.435)	(0.891)	(-0.006)	(0.009)	(-1.228)	(1.507)	(-0.966)	(-1.697)	(-0.327)	
RSR_2→V	19.700	1.333	-1.479	0.867	-0.378	-0.889	2.646	6.350	-3.267	0.257	-5.53	-16.143	-1.408	0.995
	(0.712)	(2.954)	(-1.561)	(0.786)	(-0.418)	(-0.598)	(1.297)	(1.019)	(-0.979)	(0.061)	(-1.203)	(-3.263)	(-0.191)	
RLR_1→V	132.54	1.031	0.030	-0.230	-0.552	1.481	-1.015	-9.673	-5.405	3.727	-2.442	-10.84	-11.938	0.997
	(2.292)	(1.937)	(0.037)	(-0.343)	(-0.670)	(1.202)	(-0.648)	(-1.403)	(-0.855)	(0.422)	(-0.277)	(-1.017)	(-0.817)	
RLR_2→V	208.58	0.347	0.941	-0.414	-0.865	2.505	-2.060	-16.147	-0.268	-2.059	-1.788	-7.007	-24.011	0.997
	(3.966)	(0.682)	(1.029)	(-0.713)	(-1.401)	(1.794)	(-1.187)	(-2.316)	(-0.059)	(-0.431)	(-0.396)	(-1.116)	(-2.400)	
PI_1→V	-6.248	1.209	-0.032	-0.419	0.122	1.041	-1.768	3.454	4.896	-6.349	2.306	9.198	4.162	0.998
	(-0.521)	(3.298)	(-0.048)	(-0.566)	(0.169)	(1.893)	(-2.540)	(1.028)	(0.968)	(-1.014)	(0.280)	(1.113)	(0.479)	
PI_2→V	-2.016	1.195	-0.148	-0.231	0.254	0.374	-1.247	2.185	4.229	-2.414	-2.756	14.167	2.904	0.997
	(-0.143)	(2.305)	(-0.172)	(-0.361)	(0.386)	(0.512)	(-1.052)	(0.479)	(0.689)	(-0.363)	(-0.435)	(1.959)	(0.281)	
C→V	-100.07	0.386	0.386	-0.836	1.062	-1.166	-1.302	0.0001	0.000002	-0.00003	-0.000003	0.0001	0.0001	0.998
	(-3.099)	(0.908)	(0.787)	(-1.854)	(1.109)	(-0.852)	(-1.273)	(3.945)	(-0.031)	(-0.536)	(0.040)	(1.846)	(1.319)	
RG→V	-96.156	1.150	-0.732	-0.591	0.668	0.802	-2.274	0.00006	0.00004	-0.002	-0.000008	0.00009	0.0001	0.998
	(-2.981)	(3.564)	(-1.257)	(-0.784)	(0.820)	(0.814)	(-2.943)	(3.197)	(1.978)	(-1.099)	(-0.382)	(2.332)	(1.243)	

Appendix Table 1 Continued ...

Variables[1]	b_0	b_1	b_2	b_3	b_4	b_5	b_6	d_1	d_2	d_3	d_4	d_5	d_6	R^2
RN→V	-156.65	0.508	0.528	-0.553	-0.023	-0.731	0.907	0.0002	-0.000006	0.00008	0.00005	0.0002	0.0002	0.997
	(-2.442)	(0.846)	(0.747)	(-1.108)	(-0.029)	(-0.651)	(0.963)	(2.506)	(-0.069)	(0.678)	(0.474)	(2.535)	(1.143)	
TG→V	-100.39	0.384	0.329	-0.351	0.064	-0.078	-1.388	0.00009	-0.00002	-0.00006	0.00002	0.0001	0.00009	0.995
	(-6.088)	(1.686)	(1.079)	(-1.237)	(0.222)	(-0.273)	(-3.473)	(7.805)	(0.921)	(-3.362)	(0.926)	(4.108)	(2.753)	
TN→V	-116.6	0.879	-0.109	0.056	-0.386	-0.149	0.487	0.0001	-0.00004	0.00003	0.0001	0.0001	0.0001	0.998
	(-4.094)	(2.616)	(-0.206)	(0.118)	(-0.886)	(-0.336)	(0.835)	(4.392)	(0.821)	(-0.934)	(2.788)	(2.485)	(2.352)	
R→V	10.263	1.463	-0.153	-1.084	2.513	-3.889	0.472	0.0006	-0.0014	-0.000003	0.0013	0.0022	-0.0005	0.998
	(0.751)	(3.122)	(-0.208)	(-0.699)	(1.406)	(-2.085)	(0.268)	(1.277)	(-2.724)	(-0.0042)	(1.802)	(3.1596	(-0.469)	
RT→V	-309.94	1.416	-2.799	1.361	-2.203	-1.445	1.512	0.0025	0.0019	0.0019	0.0029	0.0028	0.0057	0.992
	(-1.149)	(2.933)	(-2.918)	(1.466)	(-1.371)	(-0.645)	(0.417)	(2.239)	(0.674)	(0.735)	(0.7184)	(0.941)	(2.144)	
MG→V	33.348	2.097	-1.358	0.119	-0.303	-1.017	1.850	3.624	-6.967	12.530	-4.745	8.831	-20.651	0.998
	(1.481)	(3.842)	(-1.295)	(0.099)	(-0.266)	(-0.767)	(1.920)	(1.084)	(-2.891)	(3.386)	(-0.670)	(1.484)	(-1.795)	
T→V	-116.04	2.330	-2.1001	0.568	-0.277	0.204	-0.224	0.0064	0.0039	0.0023	0.0026	-0.0139	0.0111	0.997
	(-1.407)	(9.778)	(-4.138)	(1.049)	(-0.443)	(0.279)	(-0.349)	(2.124)	(0.994)	(-0.626)	(0.771)	(-4.231)	(3.459)	
OE→V	23.971	1.278	-0.242	-1.363	4.045	-3.382	-0.818	0.0003	-0.0004	0.00005	0.00005	0.00009	0.00002	0.993
	(1.0124)	(3.740)	(-0.354)	(-1.379)	(1.938)	(-1.796)	(-0.991)	(2.176)	(-2.114)	(0.953)	(0.984)	(1.922)	(0.286)	
CPI→V	-547.08	0.803	0.375	-0.661	0.153	0.573	-3.507	-1.992	1.139	-15.251	8.079	35.861	-6.345	0.999
	(-5.149)	(7.176)	(1.789)	(-3.367)	(0.946)	(3.447)	(-8.250)	(-0.731)	(0.279)	(-2.685)	(0.979)	(3.824)	(-0.946)	
IMP→V	-312.37	0.226	-1.163	-0.265	-0.643	-0.679	-0.589	0.349	-0.154	0.668	0.674	3.132	1.866	0.999
	(-3.956)	(0.574)	(-0.475)	(-0.892)	(-3.251)	(-2.103)	(-1.471)	(1.630)	(-0.515)	(2.170)	(1.530)	(9.953)	(1.455)	
FPI→V	-218.69	0.566	0.036	-0.204	-0.080	-0.627	0.198	0.593	-0.152	0.233	0.533	0.0399	1.904	0.999
	(-9.424)	(3.813)	(0.180)	(-1.026)	(-0.405)	(-3.075)	(0.656)	(4.966)	(-0.662)	(0.934)	(1.791)	(0.164)	(7.083)	
MY→V	-13.227	0.409	-0.266	-0.338	-1.273	-2.412	-0.500	0.0038	-0.0045	0.0082	0.0083	0.0417	0.027	0.999
	(-1.272)	(0.684)	(-0.517)	(-0.789)	(-2.319)	(-3.569)	(-0.605)	(-0.766)	(-0.702)	(1.154)	(0.815)	(7.665)	(1.023)	

Appendix Table 1 Continued ...

Variables[1]	b_0	b_1	b_2	b_3	b_4	b_5	b_6	d_1	d_2	d_3	d_4	d_5	d_6	R^2
PCMY→V	-21.036	1.175	-0.397	-0.322	-0.709	0.262	-0.732	-0.0047	-0.0014	0.015	0.031	0.0038	-0.0035	0.997
	(-1.025)	(3.254)	(-0.647)	(-0.547)	(-1.371)	(0.472)	(-1.224)	(-0.925)	(-0.225)	(2.462)	(3.466)	(0.262)	(0.269)	
CY→V	-100.27	0.824	-0.138	-0.117	1.669	0.4402	-2.899	0.079	0.0089	-0.0141	-0.049	-0.061	0.049	0.998
	(-4.363)	(2.187)	(-0.336)	(-0.276)	(1.836)	(0.5559)	(-2.252)	(2.082)	(0.2334)	(-0.611)	(-1.517)	(-1.913)	(0.922)	
PCCY→V	-218.04	1.074	-0.0606	0.023	1.117	0.137	-2.593	116.92	-16.854	-39.257	-65.787	-62.267	130.02	0.998
	(-5.938)	(5.118)	(-0.158)	(0.061)	(2.038)	(0.257)	(-3.799)	(2.575)	(-0.409)	(-0.972)	(-1.497)	(-1.387)	(3.131)	
FOP→V	-262.19	0.283	0.259	-0.381	-0.305	-0.951	1.414	0.395	0.090	0.181	0.778	-0.044	1.919	0.999
	(-12.474)	(2.089)	(1.544)	(-2.400)	(-2.243)	(-5.343)	(4.776)	(5.289)	(0.582)	(1.096)	(3.473)	(-0.269)	(9.425)	
DV→V	29.727	-98.366	-207.18	-40.309	-299.00	645.60	-0.679	100.82	306.40	347.32	646.49	2.249	-1.663	0.982
	(1.278)	(-0.277)	(-0.511)	(-0.097)	(-0.722)	(1.597)	(-0.043)	(0.284)	(0.872)	(0.887)	(1.586)	(0.139)	(-0.922)	
RDV_1→V	-99.289	-0.999	-1.2326	5.267	-4.767	-4.179	7.732	191.87	239.11	-161.75	131.45	497.02	44.690	0.991
	(-1.425)	(-0.563)	(-0.321)	(1.371)	(-1.121)	(0.874)	(1.691)	(1.457)	(1.176)	(-0.844)	(0.682)	(2.297)	(0.388)	
RDV_2→V	-39.801	0.655	-1.141	2.711	-2.478	0.145	1.039	330.84	330.31	-249.93	214.70	415.04	134.70	0.979
	(-0.303)	(0.392)	(-0.374)	(0.829)	(-0.689)	(0.038)	(0.188)	(0.882)	(0.631)	(-0.535)	(0.407)	(0.617)	(0.418)	
TT→V	1191.5	1.942	-0.571	0.757	-0.027	2.584	-6.169	1020.4	-1048.5	598.34	-1503.6	603.07	-706.71	0.994
	(2.088)	(8.171)	(-0.874)	(1.159)	(-0.035)	(3.206)	(-3.933)	(2.905)	(-2.270)	(0.984)	(-2.435)	(1.291)	(-2.388)	
RECG→V	191.67	0.014	2.695	0.519	0.397	4.251	-11.053	1126.4	-1375.8	539.16	-355.75	-1065.7	1089.5	0.997
	(21.794)	(0.045)	(6.794)	(1.250)	(0.536)	(11.395)	(-6.616)	(9.942)	(-8.314)	(3.117)	(-1.102)	(-8.012)	(11.932)	

[1] Variables are as defined in the text.
[2] t-statistics are in brackets.

Appendix 2: Regression Results

Appendix Table 2: Regression Results for Testing Bivariate Causality: Instantaneous Causality

Variables[1]	b_0	b_1	b_2	b_3	b_4	b_5	b_6	d_0	d_1	d_2	d_3	d_4	d_5	d^6	R^2
							Estimated coefficients and t-statistics[2]								
$EX \rightarrow V$	507.36	1.935	-1.667	1.648	-0.377	1.013	-0.378	-85.099	375.47	-188.40	-549.4	454.78	-420.34	150.57	0.996
	(1.4402	(3.602)	(-1.875)	(0.543)	(-0.393)	(1.149)	(-0.174)	(-0.426)	(2.116)	(-0.736)	(-2.129)	(1.593)	(-0.686)	(-0.636)	
$M \rightarrow V$	-195.84	1.713	-2.043	0.877	0.322	-1.961	0.227	-0.023	0.033	-0.017	-0.0088	0.020	-0.014	0.059	0.992
	(-1.613)	(3.326)	(-2.411)	(0.916)	(0.321)	(-1.121)	(0.115)	(-0.986)	(1.307)	(-0.596)	(-0.299)	(0.626)	(-0.534)	(1.957)	
$SR \rightarrow V$	66.378	2.410	-1.135	1.142	-0.097	0.218	-3.4933	4.865	3.189	-13.213	-1.227	2.388	3.443	16.508	0.989
	(0.596)	(2.918)	(-1.016)	(0.949)	(-0.069)	(0.158)	(-1.788)	(-0.504)	(0.443)	(-1.485)	(-0.128)	(0.264)	(0.430)	(1.652)	
$LR \rightarrow V$	-84.112	1.497	-0.179	-0.277	0.532	0.796	-2.771	-3.123	5.284	2.532	-14.737	8.178	18.993	9.323	0.994
	(-1.125)	(4.493)	(-0.256)	(-0.297)	(0.439)	(0.588)	(-2.513)	(-0.291)	(0.605)	(0.277)	(-1.473)	(0.787)	(1.585)	(0.731)	
$PI_1 \rightarrow V$	0.264	1.167	-0.546	1.189	-0.903	1.696	-3.033	8.251	-6.778	15.874	-18.231	13.433	-7.738	17.40	0.998
	(0.031)	(4.649)	(-1.087)	(1.485)	(-1.423)	(3.744)	(-4.449)	(2.590)	(-1.483)	(2.902)	(-2.906)	(1.899)	(-0.896)	(2.224)	
$PI_2 \rightarrow V$	0.762	1.359	-0.403	0.047	0.476	0.043	-1.426	5.912	-4.072	7.136	-3.566	-4.304	13.508	0.562	0.999
	(0.0749)	(3.600)	(-0.644)	(0.100)	(0.991)	(0.0798)	(-1.673)	(2.3995)	(0.974)	(1.568)	(-0.746)	(-0.939)	(2.605)	(0.075)	
$RSR_1 \rightarrow V$	34.108	1.785	-1.280	0.214	-0.3011	1.331	-0.656	-1.514	-0.292	-4.895	7.673	-5.211	-10.95	-1.472	0.994
	(1.167)	(2.009)	(-1.123)	(0.1714)	(-0.2093)	(0.847)	(-0.197)	(-0.266)	(-0.046)	(-1.137)	(1.293)	(-0.713)	(-1.2995)	(-0.176)	
$RSR_2 \rightarrow V$	27.565	1.527	-1.589	0.789	-0.047	-0.720	-1.789	-2.035	5.498	-3.055	1.287	-4.380	-15.518	-1.145	0.994
	(0.705)	(1.954)	(-1.445)	(0.637)	(-0.033)	(-0.418)	(0.514)	(-0.323)	(0.7447)	(-0.819)	(0.227)	(-0.706)	(-2.679)	(-0.140)	
$RLR_2 \rightarrow V$	164.79	0.971	0.540	-0.829	1.105	0.891	-2.828	-9.323	-7.077	0.321	0.057	4.282	-8.823	-13.934	0.999
	(6.085)	(3.431)	(1.211)	(-2.826)	(2.014)	(1.164)	(-3.342)	(-4.248)	(-1.793)	(0.149)	(0.024)	(1.658)	(-2.921)	(-2.618)	
$RLR_1 \rightarrow V$	145.96	1.139	0.589	-0.971	1.400	0.338	-2.816	-12.043	-1.417	-7.547	4.983	10.991	-14.42	-10.623	0.999
	(4.787)	(4.064)	(1.332)	(-2.413)	(2.080)	(0.474)	(-2.969)	(-3.773)	(-0.336)	(-2.248)	(1.074)	(1.886)	(-2.546)	(-1.386)	
$C \rightarrow V$	-63.716	0.589	-0.022	0.253	-0.093	0.079	-2.06	0.00004	0.00006	0.000011	-0.000014	-0.00003	0.00012	0.000092	0.999
	(-2.246)	(1.826)	(-0.056)	(0.441)	(-0.108)	(0.069)	(-2.52)	(2.313)	(1.802)	(0.302)	(-0.9998)	(-0.5399)	(2.534)	(1.124)	
$RG \rightarrow V$	-79.379	1.001	-0.369	-0.938	0.830	1.479	-2.997	0.00002	0.00006	0.00004	-0.00004	-0.00002	0.00012	0.00008	0.998
	(-1.742)	(2.303)	(-0.414)	(-0.923)	(0.901)	(0.927)	(-1.972)	(0.568)	(2.111)	(1.918)	(-1.1111)	(-0.651)	(1.660)	(0.507)	

Appendix Table 2 Continued ...

Variables[1]	b_0	b_1	b_2	b_3	b_4	b_5	b_6	d_1	d_2	d_3	d_4	d_5	d_6	R^2	
RN→V	-70.978	1.114	-0.223	0.576	-1.476	1.638	-1.315	0.00014	-0.00004	0.00016	-0.0001	0.00005	0.0002	0.000013	0.998
	(-1.531)	(2.773)	(-0.465)	(1.256)	(-2.289)	(1.651)	(-1.482)	(3.212)	(-0.4783)	(2.142)	(-1.192)	(0.7745)	(3.983)	(0.098)	
TG→V	-78.018	0.562	0.117	-0.146	0.180	-0.016	-1.619	0.00002	0.00008	0.000011	-0.00006	0.00003	0.00008	0.00009	0.999
	(-3.228)	(2.146)	(0.344)	(-0.460)	(0.619)	(-0.058)	(-3.801)	(1.219)	(4.164)	(0.493)	(-3.418)	(1.208)	(1.774)	(2.760)	
TN→V	-87.38	1.060	-0.263	0.135	-0.034	-0.111	-0.264	0.00004	0.00008	0.00003	-0.00004	0.0001	0.00007	0.00013	0.999
	(-2.975)	(3.506)	(-0.576)	(0.333)	(-0.081)	(-0.297)	(-0.402)	(1.735)	(3.075)	(0.7182)	(-1.370)	(3.246)	(1.047)	(2.584)	
R→V	27.519	1.267	-1.996	0.245	1.193	-2.471	-0.367	0.0007	-0.0008	-0.0003	0.0005	0.0010	0.0013	0.0008	0.998
	(1.566)	(2.806)	(-1.349)	(0.143)	(0.631)	(-1.214)	(-0.214)	(1.399)	(1.787)	(-0.354)	(0.783)	(1.488	(1.581)	(-0.827)	
RT→V	-287.55	0.841	-1.448	0.099	-1.328	-1.748	1.545	0.0018	0.0011	0.00085	0.0012	0.0035	0.0024	0.0049	0.999
	(-4.605)	(6.607)	(-5.484)	(0.389)	(-3.466)	(-3.369)	(1.844)	(9.451)	(3.760)	(2.068)	(2.043)	(3.678)	(3.539)	(7.908)	
MG→V	63.159	1.748	-1.017	-0.484	0.672	0.523	1.076	4.762	3.131	-6.598	7.886	-3.011	-6.067	-19.901	0.998
	(2.225)	(3.226)	(-1.052)	(-0.422)	(0.555)	(0.332)	(1.069)	(1.493)	(1.039)	(-3.036)	(1.734)	(-0.466)	(-0.536)	(-1.928)	
T→V	-147.77	2.267	-2.091	0.359	-0.071	-0.208	0.276	0.0019	0.0068	0.0054	-0.0032	0.0028	-0.015	0.011	0.997
	(-0.868)	(5.850)	(-3.699)	(0.321)	(-0.061)	(-0.102)	(0.116)	(0.221)	(1.827)	(0.647)	(-0.566)	(0.725)	(-2.118)	(2.740)	
OE→V	43.148	1.196	-1.054	1.642	1.445	-2.019	-0.819	0.0003	-0.0004	0.0004	0.000013	0.00002	0.00002	-0.00004	0.999
	(3.906)	(8.010)	(-3.077)	(2.146)	(1.365)	(-2.330)	(-2.287)	(4.745)	(0.443)	(-4.563)	(0.529)	(0.771)	(0.534)	(-1.479)	
CPI→V	-705.62	0.691	0.607	-0.844	0.109	0.461	-3.887	-4.135	2.779	-5.079	-7.822	1.503	44.255	-3.963	0.999
	(-5.631)	(6.161)	(2.789)	(-4.373)	(0.793)	(3.032)	(-9.408)	(-1.788)	(0.794)	(-1.044)	(-1.242)	(0.193)	(4.854)	(-0.689)	
FPI→V	-195.79	0.573	0.127	-0.129	0.0099	-0.443	-0.478	0.260	0.358	-0.0003	0.078	0.446	-0.112	1.914	0.999
	(-13.245)	(6.808)	(1.076)	(-1.130)	(0.086)	(-3.471)	(-1.820)	(3.399)	(3.694)	(-0.0018)	(0.526)	(2.612)	(-0.773)	(12.558)	
IMP→V	-266.64	0.363	-0.146	-0.269	-0.365	-0.434	-1.162	0.509	-0.111	-0.199	0.487	0.526	2.887	1.641	0.999
	(-4.778)	(1.348)	(-0.635)	(-1.353)	(-2.153)	(-1.839)	(-3.369)	(2.658)	(-0.492)	(-0.984)	(2.234)	(1.743)	(12.511)	(1.894)	
MY→V	-8.707	0.232	-0.068	-0.144	-1.195	-1.981	-1.324	0.005	-0.008	-0.0023	0.0018	0.0097	0.034	0.036	0.999
	(-0.636)	(0.324)	(-0.106)	(-0.251)	(-1.975)	(-1.893)	(-0.782)	(0.572)	(-0.883)	(-0.294)	(0.133)	(0.865)	(2.236)	(1.108)	

Appendix Table 2 Continued ...

Variables[1]	b_0	b_1	b_2	b_3	b_4	b_5	b_6	d_1	d_2	d_3	d_4	d_5	d_6	R^2	
PCMY→V	-24.238	1.186	-1.471	-0.303	-0.764	0.247	-0.750	-0.0022	-0.003	-0.0007	0.016	0.032	0.0046	-0.0016	0.996
	(-0.972)	(2.961)	(-0.655)	(-0.463)	(-1.276)	(0.402)	(-1.131)	(-0.310)	(-0.508)	(-0.098)	(2.209)	(3.029)	(0.286)	(-0.099)	
CY→V	-91.178	0.752	-0.143	0.017	1.692	0.548	-3.019	0.011	0.079	0.014	-0.009	-0.055	-0.0626	0.028	0.997
	(-2.350)	(1.603)	(-0.316)	(0.027)	(1.683)	(0.587)	(-2.058)	(0.328)	(1.873)	(0.312)	(-0.297)	(-1.378)	(-1.764)	(0.324)	
PCCY→V	-203.76	1.083	-0.078	0.227	1.006	0.174	-2.652	31.248	107.91	-17.797	-34.61	-73.84	-61.925	101.38	0.998
	(-4.451)	(4.814)	(-0.192)	(0.429)	(1.636)	(0.304)	(-3.601)	(0.608)	(2.125)	(-0.404)	(-0.789)	(-1.512)	(-1.290)	(1.565)	
RECG→V	122.27	0.364	1.245	0.255	-0.113	2.630	-5.295	200.98	481.01	-557.35	323.26	31.899	-681.18	752.67	0.999
	(2.279)	(0.954)	(1.073)	(0.621)	(-0.151)	(2.051)	(-1.142)	(1.306)	(0.955)	(-0.868)	(1.454)	(0.0785)	(-2.156)	(2.793)	
TT→V	689.51	1.820	-0.187	0.395	0.646	1.838	-6.188	517.71	482.59	-374.99	116.06	-1105.9	299.13	-480.81	0.995
	(1.135)	(8.023)	(-0.295)	(0.627)	(0.793)	(2.109)	(-4.424)	(1.513)	(1.019)	(-0.618)	(0.185)	(-1.812)	(0.647)	(-1.586)	
DV→V	-0.038	0.570	0.014	-0.014	0.018	0.397	0.015	0.9999	0.431	0.416	0.430	0.413	0.016	-0.0025	1.00
	(-1.005)	(1.137)	(0.024)	(-0.024)	(0.029)	(0.570)	(0.690)	(1596.2)	(0.859)	(0.787)	(0.729)	(0.589)	(0.709)	(-0.918)	
RDV_1→V	7.082	1.778	-0.725	-0.460	0.622	0.733	-1.207	77.178	-51.633	-5.251	40.271	-10.386	-50.063	23.678	0.995
	(0.366)	(3.575)	(-0.826)	(-0.434)	(0.556)	(0.609)	(-0.863)	(9.599)	(-1.314)	(-0.099)	(0.831)	(-0.224)	(-0.664)	(0.899)	
RDV_2→V	-13.491	1.590	-0.994	0.117	-0.015	0.867	-0.686	234.89	-114.21	74.220	125.37	56.104	-89.24	128.78	0.999
	(-0.462)	(4.168)	(-1.474)	(0.152)	(-0.018)	(1.013)	(-0.555)	(9.908)	(-1.211)	(0.626)	(1.139)	(0.477)	(-0.567)	(1.806)	
FOP→V	-246.42	0.298	0.319	-0.363	-0.205	-0.866	0.985	0.116	0.294	0.167	0.085	0.748	-0.123	1.902	0.999
	(-12.099)	(2.556)	(2.149)	(-2.656)	(-1.564)	(-5.376)	(2.725)	(1.669)	(3.332)	(1.189)	(0.554)	(3.873)	(-0.830)	(10.859)	

[1] Variables are as defined in the text.
[2] t-statistics are in brackets.

Appendix 3: Regression Results

Appendix Table 3: The Results of ARIMA Estimates

	ARIMA (p, d, q)	ARIMA Structure
V	2, 2, 3	$(1-B)^2 (1 - \underset{(4.57)}{1.4203} B + \underset{(-2.11)^{*}}{0.8051} B^2)V_t = (1 + \underset{(166.68)^{*}}{1.2811} B - \underset{(-0.44)}{0.1723} B^2 - \underset{(-0.03)}{0.0143} B^3)e_t + \underset{(98.41)^{*}}{0.7479}$
EX	0, 2, 1	$(1-B)^2 EX_t = \underset{(1.76)}{0.001403} + (1 + \underset{(7.40)^{*}}{0.9235} B)e_t$
M	0, 2, 1	$(1-B)^2 M_t = \underset{(3.06)^{*}}{59.96} + (1 + \underset{(6.26)^{*}}{0.8925} B)e_t$
SR	2, 1, 3	$(1-B) (1 - \underset{(5.70)^{*}}{0.8894} B + \underset{(-6.73)^{*}}{1.0101} B^2)SR_t = (1 + \underset{(2.34)^{*}}{0.7534} B - \underset{(-3.31)^{*}}{0.9775} B^2 + \underset{(0.81)}{0.2431} B^3)e_t$
LR	5, 2, 0	$(1-B)^2(1 + \underset{(-4.57)^{*}}{0.7966} B + \underset{(-2.55)^{*}}{0.5511} B^2 + \underset{(-2.36)^{*}}{0.7399} B^3 + \underset{(-2.57)^{*}}{0.8136} B^4 + \underset{(-2.99)}{0.9636} B^5)LR_t = e_t$
PI1	2, 1, 0	$(1-B) (1 - \underset{(3.19)^{*}}{0.5827} B + (\underset{(-3.03)^{*}}{0.6803} B^2)PI1_t = e_t$
PI2	2, 1, 0	$(1-B) (1 - \underset{(3.39)^{*}}{0.6533} B + \underset{(-2.48)^{*}}{0.5925} B^2)PI2_t = e_t$
RSR1	2, 1, 4	$(1-B) (1 + \underset{(-2.23)^{*}}{0.9400} B + \underset{(-0.78)}{0.3243} B^2)RSR1_t = (1 - \underset{(-2.14)^{*}}{0.992} B + \underset{(0.25)}{0.1025} B^2 + \underset{(2.69)^{*}}{0.9504} B^3 + \underset{(2.36)^{*}}{0.6945} B^4)e_t$
RSR2	0, 2, 1	$(1-B)^2 RSR2_t = (1 + \underset{(5.72)^{*}}{0.9069} e_t$
RLR1	0, 2, 1	$(1-B)^2 RLR1_t = (1 + \underset{(4.92)^{*}}{0.877} B)e_t$
RLR2	0, 2, 1	$(1-B)^2 RLR2_t = (1 + \underset{(4.80)^{*}}{0.8844} B)e_t$
C	0, 3, 2	$(1-B)^3 C_t = (1 + \underset{(8.97)^{*}}{1.5887} B - \underset{(-3.38)^{*}}{0.6454} B^2)e_t$

RG 0, 2, 1

$$(1-B)^2 RG_t = (1 + \underset{(7.96)^*}{0.9371} B)e_t$$

RN 0, 2, 3

$$(1-B)^2 RN_t = (+ \underset{(7.45)^*}{1.0498} B + \underset{(1.88)^*}{0.5117} B^2 - \underset{(-2.81)^*}{0.6028} B^3)e_t$$

TG 5, 1, 0

$$(1-B)(1 - \underset{(4.58)^*}{0.7255} B + \underset{(-0.49)}{0.0858} B^2 + \underset{(0.43)}{0.089} B^3 + \underset{(-3.05)^*}{0.7822} B^4 - \underset{(4.37)^*}{1.0001} B^5)TG_t = e_t$$

TN 4, 2, 0

$$(1-B)^2 (1 + \underset{(-2.72)^*}{0.4486} B + \underset{(-2.66)^*}{0.4749} B^2 + \underset{(-1.95)}{0.3674} > B^3 + \underset{(-4.40)^*}{0.7722} B^4)TN_t = e_t$$

CR 4, 1, 4

$$(1-B)(1 + \underset{(-2.90)^*}{0.8859} B + \underset{(-2.47)^*}{0.9362} B^2 + \underset{(-1.32)}{0.6379} B^3 + \underset{(-2.07)}{0.8515} B^4)CR_t =$$

$$(1 - \underset{(-5.03)^*}{1.331} B - \underset{(-8.30)^*}{1.515} B^2 - \underset{(-6.17)^*}{1.5468} B^3 - \underset{(-1.30)}{0.4354} B^4)e_t$$

RT 0, 2, 1

$$(1-B)^2 RT_t = \underset{(3.04)^*}{557.1} + (1 + \underset{(6.85)^*}{1.0611} B)e_t$$

OE 0, 2, 1

$$(1-B)^2 OE_t = (1 + \underset{(3.41)^*}{0.6168} B)e_t$$

CT 0, 2, 1

$$(1-B)^2 CT_t = \underset{(1.85)}{125.07} + (1 + \underset{(4.69)^*}{0.9072} B)e_t$$

MG 4, 2, 5

$$(1-B)^2 (1 - \underset{(0.12)}{0.0268} B + \underset{(-2.73)^*}{0.646} B^2 + \underset{(-0.38)}{0.1073} B^3 + \underset{(-2.84)^*}{0.8815} B^4)MG_t = (1 +$$

$$\underset{(0.25)}{0.951} B - \underset{(-0.69)}{0.2437} B^2 + \underset{(-1.30)}{0.4896} B^3 + \underset{(1.11)}{0.4051} B^4 - \underset{(-2.83)^*}{0.9007} B^5)e_t$$

CPI 2, 2, 2

$$(1-B)^2 (1 - \underset{(3.23)^*}{0.7107} B + \underset{(-2.66)^*}{0.7747} B^2)CPI_t = \underset{(14.69)^*}{0.4785} + (1 + \underset{(1.09)}{0.2386} B + \underset{(2.66)^*}{0.6427} B^2)e_t$$

FPI 2, 1, 3

$$(1-B)(1 - \underset{(32.69)^*}{1.0764} B + \underset{(-27.98)^*}{1.0053} B^2)FPI_t = (1 + \underset{(1.07)}{0.2168} B - \underset{(-0.49)}{0.1014} B^2 - \underset{(-3.69)^*}{0.7967} B^3)e_t$$

IMP	0, 3, 1	$(1-B)^3\, IMP_t = (1 + \underset{(5.80)^*}{0.9099}\; B)e_t$
MY	5, 2, 0	$(1-B)^2\, (1 - \underset{(1.24)}{0.2586}\, B - \underset{(0.23)}{0.0466}\, B^2 + \underset{(-1.82)}{0.4118}\; B^3 + \underset{(-1.84)^*}{0.4583}\; B^4 - \underset{(2.40)^*}{0.6447}\; B^5)MY_t = e_t$
PCMY	0, 2, 1	$(1-B)^2\, PCMY_t = \underset{(2.47)^*}{85.05} + (1 + \underset{(5.31)^*}{0.9133}\; B)e_t$
CY	3, 2, 0	$(1-B)^2\, (1 - \underset{(0.15)}{0.0332}\, B + \underset{(-0.57)}{0.1223}\; B^2 + \underset{(-2.55)^*}{0.9300}\; B^3)CY_t = e_t$
PCCY	0, 3, 1	$(1-B)^3\, PCCY_t = (1 + \underset{(6.61)^*}{0.9271}\; B)e_t$
FOP	2, 1, 0	$(1-B)\, (1 - \underset{(4.48)^*}{0.7715}\, B\, B + \underset{(-3.96)^*}{0.6933}\; B^2)FOP_t = \underset{(3.28)^*}{9.936} + e_t$
DV	0, 3, 1	$(1-B)^3\, DV_t = (1 + \underset{(7.76)^*}{0.9789}\; B)e_t$
RDV1	4, 2, 0	$(1-B)^2\, (1 + \underset{(-2.37)^*}{0.4986}\; B + \underset{(-2.46)^*}{0.524}\; B^2 + \underset{(-2.59)^*}{0.5575}\; B^3 + \underset{(-2.35)^*}{0.533}\; B^4)RDV1_t = e_t$
RDV2	4, 2, 0	$(1-B)^2\, (1 + \underset{(-2.57)^*}{0.5370}\; B + \underset{(-2.15)^*}{0.4601}\; B^2 + \underset{(-2.67)^*}{0.5777}\; B^3 + \underset{(-2.37)^*}{0.5217}\; RDV2_t = e_t$
TT	2, 1, 0	$(1-B)\, (1 - \underset{(3.30)^*}{0.5872}\; B + \underset{(-3.46)^*}{0.6252}\; B^2)TT_t = e_t$
RECG	2, 1, 1	$(1-B)\, (1 - \underset{(9.28)^*}{1.5073}\; B + \underset{(-4.71)^*}{0.9236}\; B^2)RECG_t = \underset{(2.24)^*}{0.0031} + (1 + \underset{(4.27)^*}{0.9895})\; B)e_t$

NOTES:

(i) Variables are as defined in the text.

(ii) ARIMA (p, d, q) denotes the order of each ARIMA model, where p = the number of autoregressive terms; d = the number of time differences; and q = the number of moving average terms.

(iii) B is a backward operator defined by $B_k X_t = X_{t-k}$ while $(1-B)^d$ represents the dth order time differences

(iv) * indicates that the test statistic is significant at the 5% level.

Appendix 4: Proposed Future Research on Land Value Determination

We recommend development and testing of a behaviourally based econometric model of farmland values. There are alternative approaches to such an analysis of the relationships underlying determination of farmland prices. In one approach, land can be viewed as being largely fixed in supply and the levels of farmland prices consequently are viewed as being affected by factors relating to the demand for land. Alternatively, land can be viewed as one of a number of factors of production and unit land value, i.e. the price of farmland, can be hypothesized to be determined by the demand for and supply of farmland offered for sale. The data series on farmland values can therefore be viewed as a series of observed equilibrium values for farmland. In this section, we outline a proposed simultaneous equation model of price determination of Alberta farmland. This model will be tested and assessed relative to a single-equation demand model approach in the subsequent ARCA Project No 87-0113 "Macro-Economic Influences on Alberta Agriculture". In the proposed model, the demand for farmland is hypothesized to be determined by net farm income, the real (long-term) interest rate and real capital gain. The inclusion of net farm income as a variable reflects not only the micro-level reactions of farm producers but may also reflect the macro-level effects of the overall economy, in particular the effect of national income and of exchange rates on the agricultural sector. The interest rate is hypothesized as an important determinant if the purchase of land is to be considered as an investment. The demand for land may arise not only because it is a factor of production, but also since it may act as a hedge against inflation. Thus, changes in capital values are postulated to play a role in determining the demand for farmland. If we assume a linear function, the demand for farmland can be specified as follows:

$$Q^{D}_{Lt} = A_0 + A_1 I_t - A_2 R_t + A_3(V_t - V_{t-1}) + U_t \qquad \text{I}$$

where:

Q^{D}_{L} = acres of land demanded,

I_t = real realized net farm income in Alberta (thousands of dollars),

R_t = real (long-term) rate of interest,

V_t = real Alberta land value per acre at time t,

$V_t - V_{t-1}$ = capital gain at time t, and

U_t = residual

The supply of farmland is assumed to be a function of its price V_t, and the interest rate, R_t. If linearity is assumed, a supply function of farmland offered for sale can be specified as:

$$Q^S_{Lt} = B_0 + B_1 V_t + B_2 R_t + V_t \qquad \text{II}$$

where

V_t = residual

In equilibrium,

$$Q^D_{Lt} = Q^S_{Lt}$$

This implies that:

$$V_t = \frac{(A_0 - B_0)}{(B_1 - A_3)} + \left(\frac{A_1}{B_1 - A_3}\right) I_t - \frac{(A_2 + B_2)}{(B_1 - A_3)} R_t + \left(\frac{A_3}{B_1 - A_3}\right) V_{t-1} + \frac{(U_t - V_t)}{(B_1 - A_3)}$$

That is, the estimating equation is:

$$V_t = C_0 + C_1 I_t + C_2 R_t + C_3 V_{t-1} + W_t \qquad \text{III}$$

where:

$$C_0 = \frac{A_0 - B_0}{B_1 - A_3},\ C_1 = \frac{A_1}{B_1 - A_3},\ C_2 = \frac{-(A_2 - B_2)}{B_1 - A_3},\ C_3 = \frac{-A_3}{B_1 - A_3},\ \text{and } W_t = \frac{U_t - V_t}{B_1 - A_3}.$$

Assuming that U_t and V_t are normally distributed, then W_t will also be normally distributed.

Further, $\frac{\partial V_t}{\partial I_t} = C_1$, and $\frac{\partial V_t}{\partial R_t} = C_2$

This model can be estimated using OLS. Estimates based on this model are reported in the subsequent study ARCA 87-0113 "MacroEconomic Influences on Alberta Agriculture."