ALBERTA

Project Rept. 89-06

RURAL ECONOMY

PROJECT REPORT

FARMING FOR THE FUTURE

Alberta
AGRICULTURE

Department of Rural Economy
Faculty of Agriculture and Forestry
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Edmonton, Canada

Macro-Economic Influences on Alberta Agriculture

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ARCA Project 87-0113

Final Report to Farming for the Future Council

Department of Rural Economy Project Report 89-06

June 1989

Acknowledgements

Financial assistance from Farming for the Future Council for this project is gratefully acknowledged.

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Abstract

A previous report (ARCA Project 85-0539: Macro-Economic Influences on Alberta Farmland Values) applied lead-lag methodologies to assess the existence and nature of the impacts of various macro-economic factors and measures of farm returns on Alberta nominal farmland values. This final report for ARCA Project 87-0113: Macro-Economic Influences on Alberta Agriculture, builds on and extends the previous study. Lead-lag methodology is applied to assess the impacts of a variety of macro-economic influences on Alberta farm income levels as well as on real farmland values. The relative impact of macro-economic influences on farm income is assessed, and a behaviourally-based model of economic factors underlying price levels for Alberta farmland is statistically tested.

Overall, there are indications of causal relationships, defined in a statistical sense, between farm input prices, as well as agricultural terms of trade, and some measures of Alberta aggregate real farm income. There are only very weak indications of causality, again defined on a statistical basis, between exchange rates, interest rates or per capita GDP and farm income. There are more indications of simultaneous relationships of exchange rates, long term real interest rates, and per capita aggregate income with farm income measures. Analysis of data defined over shorter-term periods than one year might, however, generate different conclusions. In contrast (and perhaps because of longer time lags in decision making), the analysis of the influence of a variety of macro-economic factors on real farmland values gave much clearer evidence of lead-lag relationships of a number of these with real farmland values, implying statistical causality between these influences and farmland values. The U.S.-Canadian exchange rate, the general inflation rate, and both short-term and long-term interest rates all appear to lead real farmland values, irrespective of deflator. This is also the case for farm output prices and capital gains measures. There is somewhat weaker evidence that farmland prices are led by farm input prices and the agricultural terms of trade. There is also evidence that measures of real farm income, deflated by CPI, lead farmland values. These results are generally consistent with those from the analysis of effects of macro-economic factors on nominal farmland prices in the earlier study (ARCA 85-0539) which found statistical evidence of impacts of interest rates (particularly real long run interest rates). the economy-wide

price level, GDP, and U.S.-Canadian exchange rates, on nominal farmland values in Alberta. That study also found statistical evidence of impacts of realized farm income, and the prices of farm outputs, inputs, and the resulting terms of trade, on nominal farmland values. We conclude that there are significant impacts of macro-economic influences on Alberta farmland prices and thus on the capital values of the agricultural sector.

The statistical testing of a simultaneous equation model of demand and supply for Alberta farmland led to the rejection of this model of land price determination in favour of single equation models of demand for farmland. That is, it appears that the quantities of farmland offered for sale, as represented by acres of farmland transferred, do not appreciably influence Alberta farmland prices. Alberta farmland prices appear to be most influenced by factors affecting the demand for farmland. The testing of alternative single equation models of demand for Alberta farmland suggested that previous farm receipts, lagged farmland prices, and a structural dummy variable have had the most consistent impact in explaining much of the variation in Alberta farmland prices, in both nominal and real terms. Increases in aggregate cultivated area have tended to have a positive influence on farmland prices. Increases in CPI have tended to depress nominal farmland prices. Increases in interest rates have tended to increase farmland prices. The data on farmland prices are consistent with a model of adaptive expectations applied by farmland purchasers. Estimated coefficients on the structural dummy variable are consistent with the hypothesis that more available credit in the 1970s increased land values relative to the price-depressing influence of less available credit in the early 1980s. Any such influence was no longer statistically significant by the mid to late 1980s. The impact of credit availability on farmland prices warrants further research.

Introduction

One prime objective of this study is to assess the existence and nature of predictive relationships between each of farmland values and farm income, expressed in real terms, and macro-economic forces. A number of macro-economic variables considered to be relevant to the agricultural sector, based on *a priori* reasoning, economic theory, and the results of the previous study ARCA 85-0539, are identified. The predictive relationships between measures of these variables and each of farm income and farmland values are analysed using lead-lag methodology. The relative influences of selected macro-economic variables on farm income are assessed. A behavioural model of the demand for farmland is statistically tested and evaluated.

I. Assessing the Impact of Macro-Economic Variables on Real Land Values and Farm Income Using Lead-Lag Analysis

A. Methodological Approach of Lead-Lag Analysis

The methodology used here to assess predictive relations follows the approach suggested by Granger and extended by others. As was summarized in ARCA report 85-0539, in a study of statistically based predictive relationships, a time series x_t is said to "lead" another time series y_t if current values of y can be better predicted by using the history of x than without, with all other information being used in either case. The approach has been frequently applied in empirical work, but it must be recognized as being only a statistically based, rather than a behaviourally based or theoretically based, approach to analysing economic relationships. Nonetheless, it may be useful in providing empirical evidence as to the statistical strength of relationships justified by theory. In this study it is useful in identifying which of various alternative measures of a behaviourally justified economic influence has the closest association with farm income and farmland values.

As was outlined in ARCA 85-0539, eight different predictive relationships may apply in a bivariate system of x and y. Using symbolic notation these are:

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. $x \rightarrow y$, $y \rightarrow x$, $x \leftrightarrow y$ [feedback and instantaneous relationship exists].

The causality test method that is applied in this study is the ordinary least squares (OLS) version of the Granger test. Restricted and unrestricted time series models are estimated using OLS.

In testing for $x \rightarrow y$ the following models are estimated:

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

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

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 below is compared with model B.

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

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 distributed as F with (1, T-k-m-2) degrees of freedom.

The power of the F-tests depends on the degree of auto-correlation present in the models since the test statistics obtained from regressing auto-correlated series can be overestimated and thus lead to inference of erroneous predictive relationships between variables. Auto-correlation 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 nth residual auto-correlation and L can be any number beyond which the residuals are 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. The general procedure for removing auto-correlation from the data series is to add lagged values to the model until the series is completely whitened. This can lead to low degrees of freedom where the available number of observations is small.

B. Application of Lead-Lag Methodology to Real Farm Land Values

We apply the Granger test to Alberta per acre farmland value data from 1961 to 1984 to assess whether predictive relationships may exist between land values and macro-economic variables related to the farm sector. Based on economic theory, general observation, and the results of the previous study, the U.S.-Canadian exchange rate, interest rates, gross domestic product measures, and rates of inflation are identified as the macro-economic variables of interest. In addition to these, farm output and input price indexes, farm terms of trade, different farm income measures, operating expenses, and tax paid are also considered for their possible predictive relationships with land values. The data sources and symbolic notation used in this study are as for ARCA 85-0539, except that, in contrast to the previous study, the entire analysis is carried out in real terms. The Alberta Consumer Price Index and the Alberta Implicit Price Index are used to deflate the nominal data series to obtain real value series. Thus, for each variable, we have two real value data series. One of these uses CPI and the other corresponds to the GDP deflator. Granger tests are applied for both series individually.

The first step in the application of the tests is prewhitening. To do this each data series is regressed on a successively increasing number of its own lagged values until completely whitened. The Ljung-Box Q-test is used to test the presence of auto-correlation. Models A, B and C are then estimated using the OLS technique; the dependent variable y is the per acre real value of farmland and x refers to the various other variables, each considered one at a time. Finally, F-tests are applied to test for the existence of lead-lag and instantaneous relationships among the tested variables.

C. Results and Discussion, Lead-Lag Relationships with Real Land Values

The estimates of Models B and C for CPI and implicit price index deflated series are summarized in Appendix Tables 1 to 4. The F-statistics are calculated by comparing Model A with Model B and Model B with Model C and are summarized in Tables I.1 and I.2. Tables I.1 and I.2 also give the Q-statistics calculated for each case. The symbolic notation for variables in these tables is:

V_1 denotes census reconciled real land price, Alberta

EX denotes the exchange rate of the price of a U.S. dollar in terms of Canadian dollars

PI_1 denotes the real rate of inflation, based on the percentage change in the consumer price index

SR_1 denotes the real short term interest rate

LR_1 denotes the real long term interest rate

CY_1 denotes real GDP, Alberta

$PCCY_1$ denotes per capita GDP, Alberta

RC_1 denotes real GDP of Alberta

RG_1 denotes real realized gross farm income, Alberta

RN_1 denotes real realized net farm income, Alberta

TG_1 denotes real total gross farm income, Alberta

TN_1 denotes real total net farm income, Alberta

OE_1 denotes real farm operating expenses, Alberta

Table I.1: Testing for Lead-Lag and Instantaneous Relationships: Real Land Value vs Other Variables[a]

F-statistics and Q-statistics

Variables:	Testing Model A vs Model B (lead-lag relationships) F statistics	Q statistics	Testing Model B vs Model C (instantaneous relationships) F statistics	Q statistics
EX	***6.94	*16.81	0.11	**18.99
PI_1	***7.97	9.98	0.02	10.21
SR_1	***9.96	11.03	0.28	9.84
LR_1	***11.47	10.56	1.77	5.48
CY_1T 2>*3.42		9.88	**8.36	11.91
$PCCY_1$	2.64	9.20	**9.21	*17.66
RC_1	***12.67	14.53	1.91	12.72
RG_1	***12.20	11.52	0.99	9.82
RN_1	2.87	12.59	**5.23	9.54
TG_1	***11.20	13.19	0.09	13.86
TN_1	*3.81	*16.42	*3.54	**18.75
OE_1	2.70	10.84	**6.70	14.82
TX_1	0.68	8.44	*4.78	15.29
FOP_1	***8.11	6.59	0.22	9.63
FIP_1	**4.29	18.27	2.78	*17.11
TTI	**3.63	**19.36	1.04	***26.72
G	***24.57	11.23	0.78	13.24
G_1	***31.72	*16.33	0.004	*16.23

[a] The variables are deflated by the consumer price index, Alberta.
* significant at 10% level.
** significant at 5% level.
*** significant at 1% level.

Table I.2: Testing for Lead-Lag and Instantaneous Relationships: Real Land Value vs Other Variables[a]

F-statistics and Q-statistics

Variables:	Testing Model A vs Model B (lead-lag relationships) F statistics	Q statistics	Testing Model B vs Model C (instantaneous relationships) F statistics	Q statistics
EX	**3.52	9.13	1.12	8.91
PI_2	**4.71	8.74	0.09	8.36
SR_2	***6.95	9.53	0.16	10.91
LR_2	**4.36	6.58	0.09	5.89
CY_2	2.04	6.57	***10.49	*16.42
$PCCY_2$	1.28	7.13	**8.41	**20.79
RC_2	1.86	15.03	*3.46	**18.51
RG_2	2.13	10.06	1.04	14.09
RN_2	1.13	12.59	1.07	7.17
TG_2	1.48	9.96	1.79	**19.56
TN_2	0.56	13.09	0.34	*16.08
OE_2	0.49	10.84	*4.29	10.16
TX_2	2.96	11.82	0.0001	11.78
FOP_2	3.02	6.93	0.04	7.33
FIP_2	1.90	12.56	2.48	*18.25
TTI	**3.81	13.58	1.49	**21.31
G	**5.12	11.61	0.54	13.99
G_2	***47.53	14.57	0.29	12.92

[a] deflated by implicit price index of Alberta.
* significant at 10% level.
** significant at 5% level.
*** significant at 1% level.

TX_1 denotes real farm taxes, Alberta

FOP denotes real farm output price index, Western Canada

FIP denotes real farm input price index, Western Canada

TT denotes agricultural terms of trade, Western Canada

G denotes nominal capital gain

G_1 denotes real capital gain

The subscript 1 denotes deflation by the Consumer Price Index, Alberta and the subscript 2 denotes deflation by the Alberta Implicit Price Deflator (IMPI). The data sources are as for ARCA Project 55-0539.

In examining the results it should be noted that in a few cases, auto-correlation in the residuals of the estimates of Models B and C was encountered. In a very few instances this problem could not be entirely solved by adding additional lagged dependent variables. One reason for this, and a limitation of the study, is that the number of observations is small and as a result, the number of lagged dependent variables that could be added is limited. Adding more lags reduces the degrees of freedom and thus the reliability of the estimates. However, Tables I.1 and I.2 indicate that auto-correlation does not seem to be a serious problem. At the 1% level, only the terms of trade index in Model C shows auto-correlation (Table I.1). Thus, the power of the F-test is not a concern except with the terms of trade (CPI deflated) variable.

The comparison of the calculated F-statistics given in Tables I.1 and I.2 and their various levels of significance allow inference of possible predictive relationships between land values and the other variables considered. When we test Model A against Model B, the rejection of the null hypothesis, H_0: $d_1 = d_2 = \ldots = d_m = 0$, implies that the land value is led by the variables considered to be independent in Model B. Similarly, in testing Model B against Model C, the rejection of the null hypothesis, H_0: $d_0 = 0$ implies that there is an instantaneous relationship between land values and the other variable. Table I.3 summarizes the predictive relationships between land values and other variables that are inferred from Tables I.1 and I.2.

Table I.3: Predictive Relationships: Real Land Value Versus Other Variables

Variables (X)	Relationships With Land Value (V) With CPI as Deflator		With IMPI as Deflator	
1. Exchange rate	***x → v		**x → v	
2. Inflation rate	***x → v		**x → v	
3. Short-term interest rate	***x → v		***x → v	
4. Long-term interest rate	***x → v		**x → v	
5. GDP	*x → v	**x ↔ v		***x ↔ v
6. Per capita GDP		**x ↔ v		**x ↔ v
7. Cash receipts	***x → v			x ↔ v
8. Total gross farm income	***x → v			a
9. Total net farm income	**x → v	*x ↔ v		a
10. Realized gross farm income	***x → v			a
11. Realized total farm income		**x ↔ v		a
12. Operating expenses		**x ↔ v		*x ↔ v
13. Tax paid		*x ↔ v		a
14. Farm output price index	***x → v			a
15. Farm input price index	**x → v			a
16. Terms of trade index	**x → v		**x → v	
17. Nominal capital growth	***x → v		**x → v	
18. Real capital growth	***x → v		***x → v	

[a] denotes not known (i.e., the absence of x → V or x ↔ V does not prove that x and V are statistically independent since V → x was not tested).

* denotes significant at 10% level.
** denotes significant at 5% level.
*** denotes significant at 1% level.

It appears that a number of the variables considered in the study seem to lead land values, particularly in the models where the series are deflated by the consumer price index. Variables that do not lead real land values are operating expenditures, tax paid and GDP. The indications of lead-lag relationships between exchange rates, interest rates, farm income indicators and related price indexes, as well as capital gains is consistent with expectations. However, when the data series are deflated by the implicit price index, the farm income variables do not exhibit a lead-lag relationship with land values. The relationships between land values and the variables of GDP, per capita GDP, operating expenses and tax paid, are instantaneous.

The predictive relationships inferred in Table I.3, lead to the following conclusions:

1. The monetary variables of short and long term interest rates, inflation rates, and exchange rates clearly lead real land values.
2. There is a strong lead-lag relationship between capital gains and real land values.
3. Some farm income variables also have a lead-lag relationship with real land values although these relationships are less apparent when IMPI is used as the deflator. The price variables related to farm income. such as the real farm output price index, the real farm input price index, and the terms of trade index also lead real land values.
4. The relationships between both operating expenditures and tax paid with real land values mainly occurs within one year (i.e., these are instantaneous).
5. The relationships between GDP or per capita GDP and real land values are also instantaneous.

D. Application of Lead-Lag Methodology to Assess Macro-economic and Related Impacts on Real Farm Income Levels in Alberta

The Granger test is also applied to 1961 to 1985 data to assess the effects of the macro-economic variables of the U.S. Canadian exchange rate, interest rates, rates of inflation, and aggregate income (i.e., GDP) on Alberta farm income measures. The predictive relationships that may exist between farm income measures and variables related to farm income, specifically the farm output price index, farm input price index, terms of trade index, operating expenditures, and tax paid, are also explored.

Four different farm income measures are analysed. These are total gross farm income, total net farm income, realized gross farm income, and realized net farm income. The variables are as defined in Statistics Canada *Farm Net Income Reference Manual.* The analysis is entirely in real terms. The deflators used for this purpose are the Alberta consumer price index and the Alberta implicit price index. Thus, altogether, there are eight real farm income measures, four of which correspond to the use of the CPI deflator and the other four to the use of the implicit price index. The OLS version of the Granger test is applied to all eight series to assess the predictive relationship of the specified macro-economic variables and related price series with the various farm income measures. As before, the data series are whitened. Models A, B and C are estimated for all income measures and F-tests are carried out to test for lead-lag and instantaneous relationships by testing Model A against B and Model B against C.

E. Results and Discussion, Lead-Lag Relationships with Real Farm Income Measures

The estimates of Models B and C for the eight different income data series are presented in Appendix I and in Tables I.4 to I.11. The calculated F-statistics to test Model A against Model B and Model B against Model C are also given in these tables as are the Q-statistics testing for auto-correlation. In some cases auto-correlation in the residuals of the estimates of Models B and C was encountered. Unfortunately this problem could not be entirely solved by adding more lagged dependent variables due to the small number of observations. In the cases where there is evidence of auto-correlation, caution must be applied in inferring predictive relationships indicated from the F-tests.

Inferences from the statistical tests are summarized in Tables I.12 to I.15 and a summary of these relationships is given in Table I.16. From Table I.16, it can be seen that the relationships between the other variables considered and the farm income variables are mostly instantaneous, except in the case of the farm input price index and the terms of trade index which exhibit highly significant (i.e., at the 1% level) lead-lag relationships with realized gross income (with the IMPI deflator) and realized net income (with the CPI delator).

Table I.4: Testing for Lead-Lag and Instantaneous Relationships: Real Total Gross Farm Income vs Other Variables[a]

F-statistics and Q-statistics

Variables:	Testing Model A vs Model B (lead-lag relationships) F statistics	Q statistics	Testing Model B vs Model C (instantaneous relationships) F statistics	Q statistics
EX	**6.10	11.07	*4.44	***24.39
PI_1	*3.75	**16.59	0.17	**16.91
SR_1	3.31	***28.21	3.02	***35.04
LR_1	1.24	8.52	**14.23	8.46
CY_1	1.94	*15.42	**10.62	*15.50
$PCCY_1$	**4.94	10.79	*4.88	*13.52
FOP_1	0.22	8.40	***20.49	9.44
FIP_1	**2.03	**15.78	2.76	**20.05
TTI	**0.45	8.01	***74.64	**17.31
OE_1	0.41	**16.28	***14.54	18.66
TX_1	2.35	***22.42	0.43	*14.51

[a] deflated by consumer price index of Alberta.

* significant at 10% level.
** significant at 5% level.
*** significant at 1% level.

Table I.5: Testing for Lead-Lag and Instantaneous Relationships: Real Total Gross Farm Income vs Other Variables[a]

F-statistics and Q-statistics

Variables:	Testing Model A vs Model B (lead-lag relationships) F statistics	Q statistics	Testing Model B vs Model C (instantaneous relationships) F statistics	Q statistics
EX	0.58	10.61	1.07	**18.85
PI_2	1.92	*13.75	0.05	*14.80
SR_2	1.29	10.88	1.74	*13.87
LR_2	1.38	12.57	0.02	12.68
CY_2	1.03	5.93	**7.55	***25.71
$PCCY_2$	2.12	6.24	*3.79	*14.01
FOP_2	0.90	11.09	**7.75	13.13
FIP_2	0.55	9.05	**6.70	**18.56
TTI	0.84	10.66	***16.67	5.07
OE_2	0.66	9.33	*4.64	11.77
TX_2	2.89	10.34	1.76	10.68

[a] deflated by implicit price index.

* significant at 10% level.
** significant at 5% level.
*** significant at 1% level.

Table I.6: Testing for Lead-Lag and Instantaneous Relationships: Real Realized Gross Farm Income vs Other Variables[a]

F-statistics and Q-statistics

Variables:	Testing Model A vs Model B (lead-lag relationships) F statistics	Q statistics	Testing Model B vs Model C (instantaneous relationships) F statistics	Q statistics
EX	1.99	**15.91	2.21	**16.82
PI_1	2.47	*13.68	0.87	8.00
SR_1	*4.11	8.65	0.36	6.33
LR_1	2.00	9.85	***16.67	*13.94
CY_1	2.26	**18.94	**5.99	8.73
$PCCY_1$	2.80	14.91	*3.78	11.72
FOP_1	0.69	*13.42	*4.93	*15.01
FIP_1	0.60	6.50	**8.29	9.69
TTI	2.39	12.63	3.04	9.94
OE_1	0.28	*15.13	***69.47	12.49
TX_1	1.78	***20.40	**9.85	***20.74

[a] deflated by consumer price index.

* significant at 10% level.
** significant at 5% level.
*** significant at 1% level.

Table I.7: Testing for Lead-Lag and Instantaneous Relationships: Real Realized Gross Farm Income vs Other Variables[a]

F-statistics and Q-statistics

Variables:	Testing Model A vs Model B (lead-lag relationships) F statistics	Q statistics	Testing Model B vs Model C (instantaneous relationships) F statistics	Q statistics
EX	2.33	**19.61	**9.33	***21.93
PI_2	3.45	12.03	0.04	*13.45
SR_2	1.04	*14.61	1.32	11.48
LR_2	1.44	10.43	0.18	11.28
CY_2	0.73	8.75	***12.54	12.57
$PCCY_2$	1.47	9.03	**5.79	12.79
FOP_2	0.25	12.89	1.57	*14.83
FIP_2	***9.97	10.24	0.99	**17.21
TTI	1.04	8.63	1.66	11.83
OE_2	0.69	8.00	***20.12	12.93
TX_2	3.48	*14.59	0.08	**16.66

[a] deflated by implicit price index.

* significant at 10% level.
** significant at 5% level.
*** significant at 1% level.

Table I.8: Testing for Lead-Lag and Instantaneous Relationships: Real Total Net Farm Income vs Other Variables [Real][a]

F-statistics and Q-statistics

Variables:	Testing Model A vs Model B (lead-lag relationships) F statistics	Q statistics	Testing Model B vs Model C (instantaneous relationships) F statistics	Q statistics
EX	**5.93	10.96	**5.87	10.56
PI_1	1.35	13.23	1.35	11.49
SR_1	2.29	*15.73	0.64	12.71
LR_1	*3.49	**17.95	***12.24	11.55
CY_1	1.34	7.48	2.59	11.33
$PCCY_1$	1.37	7.15	*3.86	13.31
FOP_1	1.00	3.69	***35.30	3.35
FIP_1	1.65	8.28	***21.32	**17.89
TTI	2.95	***21.95	***52.89	10.29
OE_1	0.97	10.71	**7.49	9.82
TX_1	0.66	**16.99	1.37	***23.65

[a] deflated by consumer price index of Alberta.

* significant at 10% level.
** significant at 5% level.
*** significant at 1% level.

Table I.9: Testing for Lead-Lag and Instantaneous Relationships: Real Total Net Farm Income vs Other Variables[a]

F-statistics and Q-statistics

Variables:	Testing Model A vs Model B (lead-lag relationships) F statistics	Q statistics	Testing Model B vs Model C (instantaneous relationships) F statistics	Q statistics
EX	1.36	12.24	0.03	13.13
PI_2	0.59	5.90	*4.07	9.28
SR_2	2.16	12.55	0.14	14.45
LR_2	1.40	13.87	2.59	7.66
CY_2	2.84	6.65	2.14	11.83
$PCCY_2$	2.06	6.80	*3.15	*14.79
FOP_2	0.99	5.63	***19.21	5.49
FIP_2	2.13	8.24	*4.82	8.08
TTI	0.15	7.82	***59.86	*14.68
OE_2	2.98	7.11	0.48	9.63
TX_2	0.51	*15.35	0.88	**17.38

[a] deflated by implicit price index of Alberta.

* significant at 10% level.
** significant at 5% level.
*** significant at 1% level.

Table I.10: Testing for Lead-Lag and Instantaneous Relationships: Real Realized Net Farm Income vs Other Variables[a]

F-statistics and Q-statistics

	Testing Model A vs Model B (lead-lag relationships)		Testing Model B vs Model C (instantaneous relationships)	
Variables:	F statistics	Q statistics	F statistics	Q statistics
EX	2.69	10.65	2.83	9.84
PI_1	0.70	8.77	***13.78	**17.44
SR_1	1.67	4.13	0.32	3.89
LR_1	0.97	9.16	2.23	7.57
CY_1	0.83	9.18	**5.94	7.70
$PCCY_1$	1.63	9.27	**5.35	7.66
FOP_1	1.81	8.69	3.16	10.32
FIP_1	0.13	6.76	**9.95	13.05
TTI	***19.29	***24.34	0.35	***31.51
OE_1	0.23	10.67	***24.01	8.70
TX_1	1.32	*16.17	2.21	11.28

[a] deflated by consumer price index of Alberta.

* significant at 10% level.
** significant at 5% level.
*** significant at 1% level.

Table I.11: Testing for Lead-Lag and Instantaneous Relationships: Real Realized Net Farm Income vs Other Variables[a]

F-statistics and Q-statistics

Variables:	Testing Model A vs Model B (lead-lag relationships) F statistics	Q statistics	Testing Model B vs Model C (instantaneous relationships) F statistics	Q statistics
EX	1.46	*14.91	*3.41	*15.84
PI_2	0.47	8.28	2.63	12.73
SR_2	1.11	10.68	0.06	10.79
LR_2	0.33	8.46	2.82	9.62
CY_2	*3.59	8.03	**5.29	14.08
$PCCY_2$	2.80	5.92	**4.94	12.43
FOP_2	0.99	5.63	***19.21	5.49
FIP_2	2.13	8.24	*4.82	8.08
TTI	0.15	7.82	***59.86	*14.68
OE_2	2.98	7.11	0.48	9.63
TX_2	0.51	*15.35	0.88	**17.38

[a] deflated by implicit price index of Alberta.

* significant at 10% level.
** significant at 5% level.
*** significant at 1% level.

From Table I.16, the following observations can be made.

1. The relationship between farm incomes and the variables considered are mainly instantaneous, that is, they occur within the period of one year.
2. There is some, albeit weak, evidence of a relationship between U.S.-Canadian exchange rates and farm incomes. Where such a relationship is indicated, it is mainly instantaneous.
3. There is some evidence of a relationship between real levels of farm income and CPI deflated real interest rates. The influence is confined to long term interest rates and appears to be instantaneous in nature.
4. The aggregate income influences of GDP and per capita GDP show a consistent instantaneous relationship with farm incomes.
5. Farm operating expenditure has a clear instantaneous relationship with farm income as is expected. Current levels of operating expenditures reflect current levels of farm activity which therefore influences current farm incomes.
6. Tax paid does not exhibit any statistical relationships. However, this does not exclude the possibility of lagged values of farm incomes leading tax payments.
7. There are clear relationships of farm output and input price indices and farm terms of trade with farm incomes. These are mostly instantaneous although the farm input price index and the terms of trade index appear to lead some measures of farm income.

F. The Relative Impacts of Selected Variables on Gross Farm Income

The final methodological procedure in this first part of the study is to assess the relative impacts of selected macro-economic variables on one measure of Alberta farm income, real total gross farm income, in the form of twelve naive single equation OLS regression models in which the U.S.-Canadian exchange rate; real long-run interest rate; real Alberta GDP or real per capita Alberta GDP; real farm operating expenses; and real terms of trade or real farm output and input price indexes are treated as independent variables. Deflation is by the CPI (Canada). The results of this process for 1971 to 1986 are given in Table I.17. They confirm the relatively weak positive relationship of the exchange rate variable and gross farm income, the significant negative

Table I.12: Predictive Relationships: Real Total Gross Farm Income Versus Other Variables

Variables (X)	Relationships With Total Gross Income (TG) With CPI as Deflator		With IMPI as Deflator
1. Exchange rate	**x → TG	*x ↔ TG	a
2. Inflation rate	*x → TG		a
3. Short-term interest rate	a		a
4. Long-term interest rate		**x ↔ TG	a
5. GDP		**x ↔ TG	**x↔ TG
6. Per capita GDP	**x → TG	*x ↔ TG	*x ↔ TG
7. Farm output price index		***x ↔ TG	**x ↔ TG
8. Farm input price index	a		**x ↔ TG
9. Terms of trade index		***x ↔ TG	***x ↔ TG
10. Operating expenditure		***x ↔ TG	*x ↔ TG
11. Tax paid	a		a

[a] denotes not known (i.e., the absence of x → TG

* significant at 10% level.
** significant at 5% level.
*** significant at 1% level. or x ↔ TG does not prove independence (x - TG) or TG → x because TG → x was not tested).

Table I.13: Predictive Relationships: Real Realized Gross Farm Income Versus Other Variables

Variables (X)	Relationships With Realized Gross Income (RG) With CPI as Deflator	With IMPI as Deflator
1. Exchange rate	a	**x ↔ RG
2. Inflation rate	a	a
3. Short-term interest rate	*x → RG	a
4. Long-term interest rate	***x ↔ RG	a
5. GDP	**x ↔ RG	***x ↔ RG
6. Per capita GDP	*x ↔ RG	**x ↔ RG
7. Farm output price index	*x ↔ RG	a
8. Farm input price index	**x ↔ RG	*x → RG
9. Terms of trade index	a	a
10. Operating expenditure	***x ↔ RG	***x ↔ RG
11. Tax paid	**x ↔ RG	a

[a] denotes not known (i.e., the absence of x → RG or x ↔ RG does not prove independence (x - RG) or RG → x because RG → x was not tested).

* significant at 10% level.
** significant at 5% level.
*** significant at 1% level.

Table I.14: Predictive Relationships: Real Total Net Farm Income Versus Other Variables

Variables (X)	Relationships With Total Net Income (TN)		
	With CPI as Deflator		With IMPI as Deflator
1. Exchange rate	**x → TN	**x ↔ TN	a
2. Inflation rate	a		*x ↔ TN
3. Short-term interest rate		a	a
4. Long-term interest rate	*x → TN	***x ↔ TN	a
5. GDP		a	a
6. Per capita GDP		*x ↔ TN	*x ↔ TN
7. Farm output price index		***x ↔ TN	***x ↔ TN
8. Farm input price index		***x ↔ TN	*x ↔ TN
9. Terms of trade index		***x ↔ TN	***x ↔ TN
10. Operating expenditure		**x ↔ TN	a
11. Tax paid		a	a

[a] denotes not known (i.e., the absence of x → NG or x ↔ NG does not prove independence (x - NG) or NG → x because NG → x was not tested).

* significant at 10% level.
** significant at 5% level.
*** significant at 1% level.

Table I.15: Predictive Relationships: Real Realized Net Farm Income Versus Other Variables

Variables (X)	Relationships With Realized Net Income (RN) With CPI as Deflator	With IMPI as Deflator
1. Exchange rate	a	*x ↔ RN
2. Inflation rate	***x ↔ RN	a
3. Short-term interest rate	a	a
4. Long-term interest rate	a	a
5. GDP	**x ↔ RN *x → RN	**x ↔ RN
6. Per capita GDP	**x ↔ RN	**x ↔ RN
7. Farm output price index	a	***x ↔ RN
8. Farm input price index	**x ↔ RN	*x ↔ RN
9. Terms of trade index	***x → RN	***x ↔ RN
10. Operating expenditure	***x ↔ RN	a
11. Tax paid	a	a

[a] denotes not known (i.e., the absence of x → TG or x ↔ TG does not prove independence (x - TG) or TG → x because TG → x was not tested).

* significant at 10% level.
** significant at 5% level.
*** significant at 1% level.

Table I.16: Summary of Lead-Lag and Instantaneous Relationships, Measures of Real Farm Incomes vs Other Variables

Varia-bles (X)	Lead-Lag Relationships								Instantaneous Relationships							
	Deflator: CPI				Deflator: IPI				Deflator: CPI				Deflator: IPI			
	TG	RG	TN	RN	TG	RG	TN	RN	TG	RG	TN	RN	TG	RG	TN	RN
EX	**		**						*		**			**		*
PI	*											***			*	
SR		*														
LR			*						**	***	***					
CY								*	**	**		**	**	***		**
PCCY	**								*	*	*	**	*	**	*	**
OE									***	***	**	***	*	***		
TX										**						
FOP									***	*	***		**		***	***
FIP						***				**	***	**	**		*	*
TTI				***					***		***		***		***	***

* significant at 10% level.
** significant at 5% level.
*** significant at 1% level.

Table I.17: The Effect of Macro-Economic Variables on Total Gross Farm Income, 1971-86[a,b]

Estimated Coefficients

Equation	Constant Term	EX	LR_1	CY	OE_1	FOP	TTI	R^2[c]	F-Statistic	D.W. Statistic
(1)	-0.96	1.22	-0.10	0.00001	0.67		0.01	0.96	***111.24	2.31[d]
	*(-1.31)	**(2.09)	***(-4.41)	(1.24)	***(4.31)		**(2.53)			
(2)	0.29		-0.08	0.00002	0.61		0.01	0.95	***118.94	1.84[d]
	(0.62)		***(-3.62)	**(2.39)	***(3.68)		**(1.96)			
(3)	-1.11	0.11		0.00001	0.80		0.02	0.92	***71.38	1.54[e]
	(-1.10)	(0.15)		(0.99)	***(3.82)		***(4.18)			

Equation	Constant Term	EX	LR_1	PCCY	OE_1	FOP	TTI	R^2	F-Statistic	D.W. Statistic
(4)	-1.46	1.43	-0.09	0.03	0.71		0.01	0.96	***111.97	2.28[d]
	**(-2.07)	***(2.77)	***(-4.00)	(1.29)	***(5.75)		***(2.55)			
(5)	-0.07		-0.06	0.05	0.77		0.01	0.94	***104.83	1.66[d]
	(-0.12)		***(-2.62)	*(1.64)	***(5.48)		*(1.66)			
(6)	-1.77	0.40		0.06	0.73		0.01	0.93	***79.52	1.61[e]
	**(-1.93)	(0.68)		**(1.82)	***(4.53)		***(4.14)			

Equation	Constant Term	EX	R	CY	OE_1	FOP	FIP	R^2	F-Statistic	D.W. Statistic
(7)	0.56	0.83	-0.12	0.00001	0.38	0.01	-0.004	0.95	***85.76	2.31[d]
	(0.60)	(1.01)	***(-4.49)	(0.47)	*(1.71)	**(2.03)	(-0.40)			
(8)	1.47		-0.12	0.000004	0.29	0.01	0.003	0.95	***102.63	2.16[d]
	***(6.51)		***(-4.57)	(0.31)	*(1.41)	**(1.80)	(0.40)			
(9)	-0.52	1.10		0.00003	0.67	0.03	-0.04	0.91	***50.53	1.62[e]
	(-0.41)	(0.96)		*(1.64)	**(2.24)	***(3.37)	***(3.13)			

Equation	Constant Term	EX	R	PCCY	OE_1	FOP	FIP	R^2	F-Statistic	D.W. Statistic
(10)	0.35	0.88	-0.11	0.02	0.37	0.01	-0.004	0.95	***87.02	2.30[d]
	(0.35)	(1.07)	***(-4.30)	(0.70)	*(1.68)	**(2.04)	(-0.40)			
(11)	1.36		-0.11	0.01	0.27	0.01	0.004	0.95	***103.48	2.14[d]
	***(3.74)		***(-4.40)	(0.50)	*(1.35)	**(1.80)	(0.58)			
(12)	-1.09	1.21		0.07	0.63	0.03	-0.03	0.91	***53.74	1.62[e]
	(-0.84)	(1.08)		**(2.01)	**(2.16)	***(3.20)	***(-2.98)			

[a] t-statistics are given in parentheses.

[b] *, **, *** indicates significance at the levels of 10%, 5% and 1% respectively.

[c] adjusted R^2

[d] Durbin-Watson statistics indicate no first order auto-correlation.

[e] The test for first order auto-correlation is inconclusive.

relationship of long-run interest rates and gross farm income, the weak positive relationship between the aggregate income measures and gross farm income, the significant positive association between farm operating expenses and gross farm income, the weak positive association between farm output prices and the agricultural terms of trade with gross farm income, and the weak negative association between farm input prices and gross farm income.

II. Empirical Analysis of Determination of Alberta Farmland Values

A. Review of Previous Studies

Over the years attempts have been made to model land prices in a simultaneous equation framework. Three of the best known models, presented by Herdt and Cochrane, Tweeten and Martin, and Reynold and Timmons were developed in the 1960s and are briefly reviewed here. The common belief that has motivated the simultaneous equation approach to land price analysis is that farmland prices are determined by the interaction of the forces of supply and demand. While conventionally it is recognized that the stock of land is relatively fixed, it can be argued that this does not necessarily imply a fixed land supply for market transactions because the supply function relates price to the quantity of land offered for sale, rather than to the total quantity of land. Herdt and Cochrane (1966) identified a number of factors that may contribute to changes in the demand for and supply of land, suggesting that the aggregate supply function for land slopes upward because the amount of land offered on the market will increase as land price rises, and that a farmer may decide to sell his farm when he has the opportunity for non-farm employment. Average non-farm income, the number of non-farm jobs, and the unemployment rate might all reflect such factors. In addition, high rates of returns on alternative investments might induce sales of land. A change in the total amount of land in farms could shift the supply of farmland.

The demand function for farmland is expected to be a negative function of land prices since a low land price may allow buyers to control more complementary resources and buy more land. Change in the expected income from land is viewed as a major demand factor and since expected future income must be discounted to its present value, interest rates are expected to shift the demand function. The impact of technical change in agriculture was hypothesized to have a positive effect on farmers' demand for land. The simultaneous equation model developed by Herdt and Cochrane included variables proxying some of the hypothesized factors. Both land price and quantity sold were endogenous. The model was estimated using the method of two stage least squares (2SLS).

In the same spirit, Reynold and Timmons (1969) developed a two-equation recursive model to identify the principal determinants of U.S. farmland prices from 1933 to 1965 and Tweeten and Martin (1966) presented a five-equation recursive system to explain changes in farmland values over four decades ending in the early 1960s. In these and other studies it was argued that anticipations of land value appreciation in the future, i.e., capital gains, are important in explaining apparent divergence between farm income levels and real land values. In Tweeten and Martin's study, capital gain in year t was defined as the first difference in land prices and expected capital gains were measured as the previous three-year weighted average of past capital gains.

The simultaneous equation approach is expected to provide theoretical insights into the movements of farmland prices. Each of the cited models did a reasonable job of explaining empirically variations in land prices during the period for which they were originally estimated. However, they did not forecast accurately the dramatic increases in land prices that occurred in the 1970s. Pope *et al* (1979) compared the forecast results of the Herdt and Cochrane simultaneous equation model, a single-equation econometric model developed by Klinefelter

(1973) and a statistically, rather than behaviourally, based model based on an integrated-autoregressive moving average process. Klinefelter's single equation model of land prices relied less on considerations of economic structure than did the simultaneous equation models. This author treated the number of farm transfers as exogenous and found that 97 percent of the variation in Illinois land prices between 1951 and 1970 could be explained by variables reflecting net returns, average farm size, the number of transfers, and expected capital gains. The major results of the comparison by Pope *et al.* are summarized as follows. First, the 2SLS estimates of the Herdt and Cochrane model showed better forecasting performance than did three stage least squares (3SLS) estimates of that model. Since 3SLS is more sensitive to specification error than is 2SLS, the poorer forecasting performance of the 3SLS estimates of the Herdt-Cochrane model indicates some specification error may exist in the structural equations. Secondly, Klinefelter's single equation econometric model appeared to forecast better than the simultaneous equation model. Thirdly, the Box-Jenkins analysis predicted the increase in land prices about as well as did the simultaneous equation model, but somewhat worse than the single equation model.

Pope *et al's* study indicated that modelling a supply function of agricultural land offered for sale did not add usefully to structural features of a model of farmland price determination. Burt (1986) argued that changes in the total amount of farmland are relatively insensitive to farmland prices because these are largely caused by government appropriations and urban growth. He concluded that with quantity of farmland fixed, the demand equation entirely determines prices. This author applied a classical capitalization formulation and estimated the dynamic structure of farmland prices using modern econometric time-series methods. It is possible that the time-series approach may provide better short-term forecasts than econometric models because it minimizes mis-specification errors relating to the dynamic structure and economic structure that likely occur in simultaneous equation econometric models. Nevertheless, the time-series approach has only limited scope for explaining the causal relationships between economic structure and movements of farmland prices. A better understanding of the interaction between the relevant structural variables and the motives for holding land should be beneficial to farmers and policy makers. The better forecasting performance of Klinfelter's single equation model than the naive Box-Jenkins analysis in the study by Pope *et al.* indicates that the behavioural equation approach has promise in this regard. Neither the simultaneous models nor the single equation approach have encompassed formal tests of the conjectured behavior of the supply function of farmland. The ad hoc treatment of the exogeneity of land supply introduces a potential mis-specification into farmland price determination models. If land supply is predetermined, as the single equation approach suggests, 2SLS estimates of the simultaneous equation model for land are less efficient than OLS estimates. On the other hand, if land prices are determined by the joint forces of supply and demand for land, the single equation model may generate estimation bias due to missing economic variables. Thus, a convincing assessment of each model specification for land prices cannot be obtained unless mis-specification tests are constructed.

In this study, we examine the exogeneity of the quantity of farmland transferred using the Wu-Hausman mis-specification test and proceed to develop a behavioural economic model of land price determination based on the test results.

B. The Model Specification

In the light of the behavioural relationships outlined above we postulate the following model:[2]

$$QD = D(V_t, I_t, R_t, ECG_t, CPI_t, SD_t) + u_t \qquad (1)$$

[2] This differs somewhat from (but has a stronger theoretical and behavioural basis than) the simultaneous equation model proposed in ARCA 85-0539.

$$QS_t = S(V_t, R_t, A_t, SD_t) + v_t \text{ and} \tag{2}$$

$$QD_t = QS_t \tag{3}$$

where:

QD_t = amount of land demanded at time t (100,000 acres transferred);

QS_t = amount of land supplied at time t (100,000 acres transferred);

V_t = nominal unit land values at time t (\$/acre);

I_t = expected income at time t (lagged total cash receipts in dollars in the analysis of quarterly data; lagged total gross farm income in the analysis of annual data);

R_t = rate of interest at time t (long-term government bond rate);

ECG_t = expected capital gain t time t (a 3-year weighted moving average of previous capital gains)[3]

A_t = amount of land farmed at time t ('000 cultivated acres)

SD_t = structural dummy variable equal to zero prior to 1982 (quarter 2) when Alberta land values peaked, and equal to 1 after this date.

v_t, u_t = residuals, assumed to be normally distributed with means of zero.

The data on land prices and transfer quantities are from Alberta Agriculture, *Agricultural Real Estate Situation in Alberta*. These are available on an annual basis since 1971 and on a quarterly basis since 1974. Interest rates are from the Bank of Canada, *Review*. Data on cash receipts, gross farm income, and cultivated acres are from Statistics Canada (Catalogues 22-002 and 21-001). The measure of quarterly farm cash receipts was derived from Statistics Canada's monthly receipts series; except for the current month, these data are reported as a cumulative total and are frequently revised, complicating the imputation of quarterly data.

[3] $EKG_t = 3\ (V_{t-1} - V_{t-2}) + 2\ (V_{t-2} - V_{t-3}) + (V_{t-3} - V_{t-4})\ /\ 6.$

Since land price determination is the focus of interest, 1 and 2 are redefined so:

$$V_t = \alpha_0 + \alpha_1 QD_t + \alpha_2 I_t + \alpha_3 R_t + \alpha_4 EKG_t + \alpha_5 CPI_t + \alpha_6 SD_t u_t \quad (4)$$

$$QS_t = \beta_0 + \beta_1 V_t + \beta_2 R_t + \beta_3 A_t + \beta_4 SD_t + v_t \quad (5)$$

$$QD_t = QS_t \quad (6)$$

The seasonal dummy variables D_1 to D_3 (and associated parameters α_7 to α_9 and β_5 to β_8) were added to Equations 4 and 5 to account for possible seasonality when quarterly data were used. We expected α_1 and α_3 to be negative in sign and α_2, α_4, β_1, β_2 and β_3 to exhibit positive signs.

The model was tested on nominal value data (in the form outlined above) and also with variables deflated by the CPI, rather than including CPI as a separate variable. Since quarterly data on Alberta land values and transactions are available from 1974 and the farmland price data changed from an "assurance fund" basis to a "consideration value" basis[4] in 1984 with no data overlap, we initially estimated the model using quarterly data from 1974 to 1983. The seasonal dummy variables D_1 to D_3 identify the second to fourth quarters.

C. Testing the Supply-Demand Model Specification Using the Wu-Hausman Test

In terms of Equations 4, 5, and 6, if $\beta_1 = 0$, then the quantity of transactions ($QD_t = QS_t$) is predetermined, cov $(QD_t, u_t) = 0$, and Equations 4 and 5 can be consistently estimated using ordinary least squares (OLS). However, if $\beta_1 \neq 0$, the quantity of transactions is endogenous, QD_t and u_t are correlated as are V_t and v_t, and OLS will generate biased and inconsistent estimates of the coefficients. In this situation, 3SLS or 2SLS will be the more appropriate estimation method for the simultaneous equation model. We apply the Wu-Hausman test to test the null hypothesis that $\beta_1 = 0$ or cov $(QD_t, u_t) = 0$. The Wu-Hausman test compares the performance of both OLS estimates and instrumental variable estimates under the

[4] The former reflected buyers' statements of the value of the property as stated in the Affidavit of Transferee that accompanied registration of a change of title under the Land Titles Act; the latter is the selling price of the real estate (Woloshyn *et al*).

null and alternative hypothesis. If the null hypothesis holds, both sets of estimates are consistent. The Wu-Hausman statistic tests the difference between the estimates. It is defined as:

$$T = (\hat{\beta}_{1OLS} - \hat{\beta}_{1IV})^2 / (\text{var}(\hat{\beta}_{1IV}) - \text{var}(\hat{\beta}_{1OLS}))$$

T is assymptotically distributed as chi-squared.

The model is estimated using OLS for Equations 4 and 5 and 2SLS for the simultaneous model of Equations 4, 5, and 6 (2SLS is used since, while the demand equation is exactly identified, the supply equation is overidentified). The resulting estimates are in Tables II.1 and II.2. The Wu-Hausman test is applied to the model using quarterly data from 1974 to 1983. For the model fitted in nominal terms (Table II.1), the test statistic is 0.109; for the model fitted in real terms (Table II.2), it is 1.34; in each case this is less than the critical value of χ^2 at the 95% level (3.841), suggesting that there is not a simultaneous relationship between land values and the amount of land transferred. This conclusion is reinforced by the feature that in both instances the estimated coefficients on land quantity in the demand equation and land prices in the supply equation are not statistically significant. In fact, the proposed supply equation in nominal terms does not appear to be well specified since none of the estimated coefficients, except those for dummy variables, are highly significant (although real interest rates and the capital gain variable have significant coefficients in the proposed real value supply function). A similar conclusion of a lack of a simultaneous relationship between farmland prices and acres transferred arises from testing the model on annual data from 1971 to 1987. In view of the Wu-Hausman test results, we reject the simultaneous equation model and focus attention on the proposed demand function for land.

We subsequently deleted the statistically insignificant coefficients from Equation 4 and retested this in both nominal and real terms using OLS. The results are in Table II.3. Equation 4 in nominal and real versions was also tested on annual data for 1971 to 1987. The single equation

Table II.1: OLS and 2SLS Estimates of Model of the Determination of Alberta Nominal Farmland Prices[a]

Equation	α_0 (Intercept)	α_1 (Transfers)	α_2 (Revenue)	α_3 (Interest Rate)	α_4 (Capital Gain)	α_5 (CPI)	α_6 (SD)	α_7 (D_1)	α_8 (D_2)	α_9 (D_3)	Adjusted R^2	F-Statistic	D-W Statistic
					Estimated Coefficients from OLS Procedure								
Demand Function	-245.68 ***(4.16)	0.04 (0.58)	2.12 **(2.24)	0.37 (0.10)	0.45 *(1.54)	5.90 ***(8.86)	-85.26 ***(-4.61)	-3.35 (0.31)	-18.52 (-1.08)	-5.52 (-0.56)	0.97	***134.19	##1.38
	β_0 (Intercept)	β_1 (Price)		β_2 (Interest Rate)	β_3 (Land Area)		β_4 (SD)	β_5 (D_1)	β_6 (D_2)	β_7 (D_3)			
Supply Function	491.82 (0.32)	-0.50 (-0.99)		2.05 (0.14)	0.01 (0.15)		-78.45 (-1.55)	109.78 ***(3.07)	252.76 ***(7.25)	41.26 (1.16)	0.72	***13.7	#0.93
					Estimated Coefficients from 2SLS Procedure								
	α_0 (Intercept)	α_1 (Transfers)	α_2 (Revenue)	α_3 (Interest Rate)	α_4 (Capital Gain)	α_5 (CPI)	α_6 (SD)	α_7 (D_1)	α_8 (D_2)	α_9 (D_3)			D-W
Demand Function	-292.46 (-1.66)	0.09 (0.45)	1.84 *(1.34)	0.54 (0.15)	0.33 (0.62)	6.16 ***(5.47)	-87.13 ***(-4.38)	-7.56 (-0.41)	-27.99 (-0.74)	-6.19 (-0.61)			##1.32
	β_0 (Intercept)	β_1 (Price)		β_2 (Interest Rate)	β_3 (Land Area)		β_4 (SD)	β_5 (D_1)	β_6 (D_2)	β_7 (D_3)			
Supply Function	-1257.50 (-0.60)	-1.19 (-1.65)		19.58 (0.99)	0.08 (0.97)		-84.68 *(-1.62)	99.58 **(2.65)	255.79 ***(7.09)	29.27 (0.78)			#1.019

[a] t-statistics are in parentheses.
* denotes significance at 10% level.
** denotes significance at 5% level.
*** denotes significance at 1% level.
# D-W statistic indicates first order auto-correlation at 5% level of significance.
D-W statistic falls in the inconclusive range at 5% level of significance.

Table II.2: OLS and 2SLS Estimates of Model of the Determination of Real Alberta Nominal Farmland Prices[a]

Equation										Adjusted R^2	F-Statistic	D-W Statistic
					Estimated Coefficients from OLS Procedure							
	α_0 (Intercept)	α_1 (Transfers)	α_2 (Revenue)	α_3 (Interest Rate)	α_4 (Capital Gain)	α_6 (SD)	α_7 (D_1)	α_8 α_8 (D_2)	α_9 (D_3)			
Demand Function	223.40 **(2.67)	-0.11 (-1.06)	1.51 *(1.34)	18.84 ***(4.54)	1.53 (2.01)	-15.32 (-0.62)	4.56 (0.21)	22.39 (0.68)	-19.05 (-0.86)	0.57	**6.84	#1.05
	β_0 (Intercept)	β_2 (Price)	β_3	β_4 (Interest Rate)	β_5 (Land Area)	β_6 (SD)	β_7 (D_1)	β_8 (D_2)	β_9 (D_3)			
Supply Function	1730.70 ***(4.41)	0.01 (0.12)		10.88 ***(3.16)	0.08 ***(5.08)	-104.49 ***(-5.02)	-13.01 (-0.74)	5.64 (0.23)	-4.94 (-0.33)	0.74	***15.17	#0.87
					Estimated Coefficients from 2SLS Procedure							
	α_0 (Intercept)	α_1 (Transfers)	α_2 (Revenue)	α_3 (Interest Rate)	α_4 (Capital Gain)	α_6 (SD)	α_7 (D_1)	α_8 (D_2)	α_9 (D_3)			
Demand Function	1293.6 (1.39)	-1.55 (-1.25)	2.61 (0.76)	-8.35 (0.32)	2.95 (1.17)	-125.02 (-1.07)	159.31 (1.10)	347.27 (1.20)	25.16 (0.34)			#0.93
	β_0 (Intercept)	β_1 (Price)	β_2	β_3 (Interest Rate)	β_4 (Land Area)	β_6 (SD)	β_7 (D_1)	β_8 (D_2)	β_9 (D_3)			
Supply Function	3956.00 (1.49)	1.32 (0.92)		-27.32 (-1.53)	-0.15 (-1.18)	77.20 (0.48)	132.44 ***(3.05)	235.62 ***(5.64)	51.03 (1.28)			#0.85

[a] t-statistics are in parentheses.
* denotes significance at 10% level; **, at 5% level; and ***, at 1% level.
# D-W statistic indicates first order auto-correlation at 5% level of significance.
D-W statistic falls in the inconclusive range at 5% level of significance.

Table II.3: Results of Single Equation Models of Alberta Farmland Demand Fitted in Real and Nominal Value Quarterly Data[a]

Equation Type	Estimated Coefficients												
	α_0 (Intercept)	α_2 (Revenue)	α_3 (Interest Rate)	α_4 (Capital Gain)	α_5 (CPI)	α_6 (SD)	α_7 (D_1)	α_8 (D_2)	α_9 (D_3)	α_{10} (Acres)	Adjusted R^2	F-Statistic	D-W Statistic
Nominal Values 1974-83	-213.73 ***(-9.94)	2.33 ***(2.89)		0.55 **(2.37)	5.76 ***(13.40)	-84.78 ***(-6.20)	-0.51 (-0.06)	-12.31 (-1.02)	-5.01 (-0.53)		0.97	***183.39	##1.45
	β_0 (Intercept)	β_2 Revenue	β_3 (Interest) Rate)	β_4 (Capital) Gain)	β_5 (CPI)	β_6 (SD)	β_7 (D_1)	β_8 (D_2)	β_9 (D_3)	β_{10} (Acres)	Adjusted R^2	F-Statistic	D-W Statistic
Real Values 1974-83	1591.50 ***(-4.46)	0.97 (1.15)	10.94 ***(3.21)	0.92 *(1.61)		-80.89 ***(-3.51)	-14.75 (-1.03)	-6.88 (-0.39)	-16.78 (-0.03)	0.07 ***(4.87)	0.76	***15.08	##1.26
	α_0 (Intercept)	α_2 (Revenue)	α_3 (Interest Rate)	α_4 (Capital Gain)	α_5 (CPI)	α_6 (SD)	α_7 (D_1)	α_8 (D_2)	α_9 (D_3)	α_{10} (Acres)	Adjusted R^2	F-Statistic	D-W Statistic
Nominal Values 1974-87	-67.23 **(-2.10)	5.59 ***(5.20)	23.28 ***(5.98)			-20.93 *(-1.34)	-19.61 (-1.22)	-39.27 **(-2.12)	-17.84 (-1.12)		0.84	***4.50	#1.11
	α_0 (Intercept)	α_2 (Revenue)	α_3 (Interest Rate)	α_4 (Capital Gain)	α_5 (CPI)	α_6 (SD)	α_7 (D_1)	α_8 (D_2)	α_9 (D_3)	α_{10} (Acres)	Adjusted R^2	F-Statistic	D-W Statistic
Real Values 1974-87	-155.74 (-0.72)	1.33 *(1.62)	19.40 ***(6.70)	1.17 **(2.26)		-99.64 ***(-4.68)	-11.82 (-0.87)	-7.16 (-0.45)	-32.91 **(-2.14)	0.01 *(1.44)	0.73	***18.65	#0.99

[a] t-statistics are in parentheses.
* denotes significance at 10% level; **, at 5% level; and ***, at 1% level.
# D-W statistic indicates first order auto-correlation at 5% level of significance.
D-W statistic falls in the inconclusive range at 5% level of significance.

models of the demand for land are in Table II.4. Examination of the results in Tables II.3 and II.4 indicates that for 1971 to 1983, lagged gross farm income and previous change in the capital values of farmland are strongly associated with the levels of nominal farmland prices as is the level of prices in the general economy while real interest rates are associated with the levels of real farmland prices. There is an evident pattern of seasonality in the quarterly land price data. There are poorer results from testing the models on data for 1971 to 1987, probably due to the change in the nature of the land price data in 1984. The results of the annual data analysis (Table II.4) are generally consistent with those based on quarterly data although lagged gross income is not significant. The equation expressed in real value terms has the benefit of not suffering from auto-correlation (which is a problem with the results in Tables II.1 to II.3) and suggests that the real interest rate, lagged real capital gains, and area of cultivated acreage have significant positive effects on real land values.

The estimated coefficients in the structural change variable suggest that the process of price determination that applied until the peak of Alberta farmland values in the early 1980s was quite different than subsequently. That is, factors beyond those expressly included in the equation have changed significantly, exerting a negative effect on farmland values. We hypothesize that this may be due to changes in the institutional conditions affecting farmland purchases, such as more stringent conditions of credit availability for these purchases. It is also possible that buyers' expectations of farmland prices may have been more pessimistic since the peak of farmland prices, a feature that led us to examine the hypothesis of adaptive expectations in buyers' decisions relating to farmland prices.

Table II.4: Results of Single Equation Models of Determination of Alberta Farmland Prices, Fitted in Real and Nominal Annual Data[a]

Equation Type	Estimated Coefficients (Intercept)	(Expected Revenue)	(Interest Rate)	(Expected Capital Gain)	(CPI)	(Area)	Adjusted R^2	F-Statistic	D-W Statistic
Nominal Values	-55.0 (0.64)	0.06 (0.14)	10.80 (1.33)	1.98 ***(3.37)	2.30 *(1.53)	0.02 (0.44)	0.96	***56.28	##1.13
Real Values	-820.91 **(-2.34)	-0.46 (-1.54)	33.47 ***(4.80)	4.48 ***(6.07)		0.04 ***(2.99)	0.89	***20.57	###2.21

[a] t-statistics are in parentheses.
* denotes significance at 10% level.
** denotes significance at 5% level.
*** denotes significance at 1% level.
\# D-W statistic indicates first order auto-correlation at 5% level of significance.
\## D-W statistic falls in the inconclusive range at 5% level of significance.
\### D-W statistics indicate no autocorrelation.

D. Econometric Test of the Hypothesis of Adaptive Expectations in the Determination of Alberta Farmland Prices

The model of adaptive expectations applied to farmland prices postulates that the demand for farmland is a function of expected farmland prices (and other factors) and that these expectations are periodically reformulated based on a fraction of the difference between actual farmland prices and expected prices, which reflect the economic bid price for land (V^*_t) determined by the capitalization formula:

$$V^*_t = NR_t/R$$

where NR_t: reflects net returns from land ownership (returns from farming, plus change in capital asset value); and R reflects the appropriate discount rate.

Further details of the adaptive expectations model are in Gorecki. Such a model is applied to Saskatchewan farmland price prediction by Weisensal *et al.*

Application of the adaptive expectations hypothesis leads to the model:

$$V_t = (1-\lambda)\,\gamma_0 + (1-\lambda)\,\gamma_1\,NR_t + \lambda\,V_{t-1} + (u_t-\lambda u_t-1) \tag{7}$$

where λ is the expectations coefficient. Equation 7 was estimated by adding to the variants of the single equation demand model, the term λV_{t-1}. Variables which had no significant impact in the context of Equation 7 were deleted and the model was re-estimated using OLS.

The results of Equation 7, reported in Tables II.5 and II.6, are an improvement on those reported in Table II.3 and II.4. The data on farmland values are consistent with the hypothesis that land purchasers adapt their expectations of Alberta farmland prices based on differences between previous expectations and land values. No problems of autocorrelation are evident. It appears that lagged farm receipts, lagged farmland prices, and the specified dummy variables account for much of the variation in Alberta farmland prices. The declines in the level and significance of the structural dummy variable in the model fitted to more recent data suggest that this impact, hypothesized to be

Table II.5: Results of Single Equation Models of Determination of Alberta Farmland Prices, Based on Adaptive Expectations of Land Prices, Fitted in Real and Nominal Value Quarterly Data[a]

	Estimated Coefficients									
Equation	(Intercept)	(Lagged Price)	(Expected Revenue)	(Area)	(SD)	(D_1)	(D_3)	Adjusted R^2	F-Statistic	D-H[b] Statistic
Nominal Values 1974-83	-351.65 *(-1.51)	0.89 ***(16.73)	0.99 **(2.12)	0.01 *(1.54)	31.12 **(3.42)	-2.55 (0.42)	-17.36 ***(-2.67)	0.98	***394.50	-1.32
Real Values 1974-83	-496.28 *(-1.79)	0.77 ***(8.51)	0.55 (1.28)	0.02 *(1.88)	-39.26 ***(-2.68)	-6.18 (-0.77)	-20.40 **(-2.40)	0.91	***58.77	-1.49
	(Intercept)	(Lagged Price)	(Expected Revenue)	(Interest Rate)	(SD)	(D_1)	(D_3)	Adjusted R^2	F-Statistic	D-H[b] Statistic
Nominal Values 1974-87	5.68 (0.44)	0.86 ***(16.85)	0.73 *(1.73)	3.44 *(1.76)	-6.88 (-1.13)	-10.06 *(-1.87)	-31.25 ***(-5.36)	0.98	***341.64	-1.31
Real Values 1974-87	34.47 *(1.89)	0.91 ***(11.54)	0.55 *(1.48)	-0.80 (-0.37)	-11.62 *(-1.34)	-9.78 *(-1.59)	-30.64 ***(-4.70)	0.93	***108.27	-1.59

[a] t-statistics are in parentheses.

[b] Durbin-H statistics. None of these suggest auto-correlation is a problem in the models reported here.

* denotes significance at 10% level.

** denotes significance at 5% level.

*** denotes significance at 1% level.

Table II.6: Results of Single Equation Models of Determination of Alberta Farmland Prices, Based on Adaptive Expectations of Land Prices, Fitted in Real and Nominal Value Annual Data[a]

	Estimated Coefficients									
Equation	(Intercept)	(Lagged Price)	(Expected Revenue)	(Interest Rate)	(Area)	(CPI)	(SD)	Adjusted R^2	F-Statistic	D-H[b] Statistic
Nominal Values	-1065.90 ***(-2.19)	1.02 ***(7.43)	0.23 (1.04)	8.11 (1.62)	0.05 **(2.24)	-2.71 **(-2.14)	-56.48 **(-2.60)	0.99	***161.63	-0.65
Real Values	56.61 *(1.75)	0.86 ***(8.70)	0.16 (0.85)	-3.04 (-0.52)			4.21 (-1.32)	0.94	***49.71	1.12

[a] t-statistics are in parentheses.

[b] Durbin-H statistics. None of these suggest auto-correlation is a problem in the models reported here.

* denotes significance at 10% level.

** denotes significance at 5% level.

*** denotes significance at 1% level.

due to less available credit since the peak of land values, may have had an appreciable negative impact on Alberta land values in the earlier 1980s, but is less apparent when data for the mid to late-1980s is analysed. The area of cultivated acreage appears to have had some influence on farmland values as have interest rates and the rate of inflation. The directions of these effects are generally consistent with expectations based on economic theory. The results from testing Equation 7 indicate that, all other things being equal, increases in interest rates have tended to increase farmland values and increases in the general level of prices in the economy (CPI) have tended to depress nominal farmland values.

E. Summary and Conclusions from Land Value Analysis

The statistical testing of a simultaneous equation model of demand and supply for Alberta farmland led to the rejection of this model of land price determination in favour of single equation models of demand for farmland. That is, it appears that the quantities of farmland offered for sale, as represented by acres of farmland transferred, do not appreciably influence Alberta farmland prices. Alberta farmland prices appear to be most influenced by factors affecting the demand for farmland. The testing of alternative single equation models of demand for Alberta farmland suggested that previous farm receipts, lagged farmland prices, and a structural dummy variable have had the most consistent impact in explaining much of the variation in Alberta farmland prices, in both nominal and real terms. Increases in the area of cultivated acreage have tended to have a positive influence on farmland prices. Increases in the consumer price index have tended to depress nominal farmland prices. Increases in interest rates have tended to increase farmland values. The data on farmland prices are consistent with a model of adaptive expectations applied by farmland purchasers. Estimated coefficients on the structural dummy variable are consistent with the hypothesis that more available credit in the 1970s increased land values relative to a price-depressing influence of less available credit in the early

1980s. Any such influence was no longer statistically significant by the mid to late 1980s. The impact of credit availability on farmland prices seems to warrant further research.

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Appendices 1 to 4: Results of Lead-Lag Model Estimations

Appendix Table 1: Lead-Lag Relationship: Land Value vs Other Variables [Real][a]
Estimates of Model B (coefficients and t-statistics[c])

Other Vari-ables	b_0	b_1	b_2	b_3	b_4	d_1	d_2	d_3	d_4	d_5	d_6
EX	3.652 (1.878)	1.656 (5.671)	-0.988 (-1.898)	0.388 (0.086)	0.298 (1.314)	4.068 (2.376)	-1.922 (-0.758)	-7.942 (-3.325)	4.686 (1.446)	-2.002 (-0.944)	--
PI_1		1.308 (4.313)	-0.534 (-1.049)	-0.245 (-0.561)	0.069 (0.316)	-0.007 (-0.190)	0.099 (1.634)	-0.108 (-1.324)	0.102 (1.136)	0.107 (1.356)	--
SR_1	0.567 (4.800)	1.437 (5.659)	-0.490 (-0.935)	-0.308 (-0.592)	0.267 (0.998)	-0.076 (-2.963)	-0.039 (-1.419)	0.101 (3.038)	-0.032 (-0.733)	-0.152 (-3.237)	--
LR_1	1.296 (5.324)	1.171 (4.618)	-0.273 (-0.595)	-0.439 (-1.105)	0.378 (1.908)	-0.085 (-2.609)	-0.087 (-1.894)	0.091 (1.655)	-0.061 (-0.944)	-0.156 (-2.531)	--
CY	-0.455 (-1.335)	1.571 (5.244)	-1.277 (-2.413)	0.714 (1.296)	-0.209 (-0.663)	0.0005 (1.916)	-0.0004 (-1.290)	--	--	--	--
PCCY	-1.026 (-1.571)	1.571 (5.244)	-1.277 (-2.413)	0.765 (1.324)	-0.223 (-0.668)	0.935 (1.625)	-0.644 (-1.073)	--	--	--	--
RC_1	-2.771 (-6.332)	0.661 (2.943)	-0.258 (-0.799)	-0.038 (-0.113)	-0.354 (-1.577)	0.794 (4.624)	0.346 (1.296)	-0.400 (-1.598)	0.283 (0.814)	1.308 (3.713)	--
RG_1	-4.619 (-4.344)	0.249 (0.731)	-0.075 (-0.230)	-0.132 (-0.409)	-0.513 (-2.167)	0.799 (4.829)	0.674 (1.988)	-0.124 (-0.491)	0.259 (0.859)	1.193 (3.819)	0.799 (1.735)
RN_1	-1.713 (-2.667)	1.368 (4.621)	-0.444 (-0.789)	-0.201 (-0.356)	0.219 (0.643)	1.321 (2.492)	-0.277 (-0.405)	-0.0008 (-0.001)	0.632 (0.964)	1.067 (1.731)	--
TG_1	-3.706 (-4.913)	0.528 (1.758)	-0.293 (-0.778)	0.059 (0.164)	-0.384 (-1.739)	0.732 (4.629)	0.334 (1.184)	-0.202 (-1.049)	0.491 (2.396)	0.759 (2.674)	0.597 (2.108)

...continued

Appendix Table 1 - Continued

Other Vari-ables	b_0	b_1	b_2	b_3	b_4	d_1	d_2	d_3	d_4	d_5	d_6
TN_1	-1.365 (-2.259)	1.501 (4.662)	-0.738 (-1.272)	0.089 (0.166)	0.116 (0.375)	0.993 (2.828)	-0.261 (-0.759)	-0.198 (-0.608)	0.859 (2.586)	0.544 (1.256)	--
OE_1	-1.865 (-2.758)	1.286 (2.920)	-1.285 (-1.710)	0.622 (0.770)	-1.008 (-1.707)	0.248 (0.289)	0.153 (0.154)	0.710 (0.649)	0.359 (0.187)	1.839 (1.175)	--
TX_1	4.488 (1.929)	1.641 (4.624)	-1.212 (-1.808)	0.391 (0.542)	-0.087 (-0.212)	-22.860 (-0.769)	-9.213 (-0.254)	-16.144 (-0.445)	-3.218 (-0.091)	-27.180 (-0.948)	--
FOP	-0.289 (-2.166)	1.311 (5.868)	-1.137 (-2.883)	0.746 (1.722)	-0.814 (-3.104)	0.032 (3.610)	-0.044 (-2.386)	0.057 (2.442)	-0.041 (-1.889)	0.051 (3.600)	--
FIP	0.117 (0.215)	1.487 (3.904)	-0.448 (-0.741)	-1.135 (-1.539)	0.631 (0.793)	0.057 (2.138)	-0.082 (-2.124)	-0.013 (-0.277)	0.201 (2.964)	-0.141 (-2.097)	--
TTI	-3.759 (-3.480)	1.532 (6.609)	-0.961 (-2.089)	0.465 (0.939)	-0.066 (-0.224)	0.040 (2.624)	-0.019 (-1.605)	0.028 (1.963)	-0.021 (1.699)	0.026 (3.265)	--
G	-0.063 (-0.476)	2.122 (6.799)	-1.402 (-3.183)	1.051 (1.346)	-0.327 (-0.577)	2.969 (9.489)	-2.753 (-3.043)	1.016 (1.101)	0.502 (0.505)		--
G_1	-0.176 (-1.128)	1.912 (6.089)	-1.324 (-2.193)	0.039 (0.046)	0.414 (0.461)	3.454 (11.179)	-2.350 (-2.439)	0.188 (0.194)	2.007 (1.502)		--

[a] deflated by consumer price index of Alberta.
[c] t-statistics are given in parentheses.

Appendix Table 2: Lead-Lag Relationship: Land Value vs Other Variables [Real][b]
Estimates of Model B (coefficients and t-statistics)[c]

Other Variables	b_0	b_1	b_2	b_3	b_4	d_1	d_2	d_3	d_4	d_5	d_6
EX	5.319 (2.399)	1.268 (3.994)	-0.631 (-1.205)	0.067 (0.127)	0.220 (0.712)	2.438 (1.012)	1.802 (0.582)	-6.484 (-2.129)	0.825 (0.228)	-3.247 (-1.185)	--
SR_2	0.443 (2.483)	1.263 (7.190)	-0.448 (-1.364)	0.107 (0.308)	0.002 (0.007)	-0.068 (-2.493)	0.019 (0.629)	-0.012 (-0.336)	0.057 (1.464)	-0.164 (-4.866)	--
LR_2	0.847 (3.698)	1.367 (6.571)	-0.730 (-1.889)	0.256 (0.609)	-0.017 (-0.063)	-0.061 (-1.889)	0.019 (0.491)	-0.046 (-1.176)	0.032 (0.813)	-0.131 (-3.797)	--
PI_2	0.577 (2.864)	1.375 (6.545)	-0.793 (-2.088)	0.318 (0.772)	-0.249 (-0.943)	0.011 (0.415)	-0.007 (-0.201)	0.041 (1.193)	-0.034 (-0.968)	0.114 (3.764)	--
CY	0.156 (0.596)	1.401 (4.122)	-0.899 (-1.753)	0.055 (0.099)	-0.028 (-0.078)	0.0001 (0.083)	0.000 (0.098)	--	--	--	--
PCCY	-0.486 (-0.869)	1.542 (4.778)	-0.953 (-1.789)	0.080 (0.137)	0.073 (0.200)	0.112 (0.168)	0.165 (0.239)	--	--	--	--
RC_2	-5.587 (-2.413)	1.064 (3.023)	-0.323 (-0.607)	-0.298 (-0.512)	0.094 (0.225)	0.986 (2.040)	0.222 (0.405)	-0.423 (-1.013)	0.710 (1.125)	0.841 (1.284)	--
RG_2	-11.435 (-2.859)	0.786 (2.076)	-0.246 (-0.486)	-0.174 (-0.308)	-0.167 (-0.385)	0.976 (1.945)	0.884 (1.366)	0.218 (0.388)	0.208 (0.327)	1.318 (1.890)	0.868 (1.348)
RN_2	-3.600 (-1.678)	1.706 (5.844)	-0.528 (-0.902)	-0.657 (-0.959)	0.813 (1.517)	1.709 (1.606)	-0.707 (-0.673)	0.115 (0.139)	1.113 (1.279)	0.522 (0.787)	--
TG_2	-4.352 (-1.589)	1.554 (4.535)	-1.145 (-1.952)	0.444 (0.714)	-0.187 (-0.479)	0.082 (0.227)	0.449 (1.385)	-0.130 (-0.477)	0.570 (2.023)	0.044 (0.112)	0.677 (2.209)

...continued

Appendix Table 2 - Continued

Other Vari-ables	b_0	b_1	b_2	b_3	b_4	d_1	d_2	d_3	d_4	d_5	d_6
TN_2	-0.107 (-0.058)	1.769 (5.328)	-1.004 (-1.515)	0.050 (0.072)	0.144 (0.311)	-0.051 (-0.101)	0.089 (0.231)	-0.315 (-0.838)	0.484 (1.259)	0.066 (0.141)	--
OE_2	-1.722 (-0.982)	1.622 (4.252)	-0.852 (-1.272)	-0.223 (-0.299)	-0.114 (-0.196)	-0.213 (-0.195)	0.240 (0.231)	0.649 (0.608)	1.161 (0.829)	-0.212 (-0.179)	--
TX_2	4.603 (3.775)	1.129 (4.053)	-0.497 (-1.062)	-0.331 (-0.651)	0.136 (0.443)	-13.444 (-1.267)	1.335 (0.083)	-2.335 (-0.144)	-3.837 (-0.245)	-23.437 (-1.885)	--
FOP	0.793 (3.125)	1.031 (3.555)	-0.372 (-0.793)	-0.284 (-0.539)	-0.206 (-0.595)	0.006 (0.385)	0.004 (0.128)	0.006 (0.192)	-0.009 (-0.314)	0.035 (1.882)	--
FIP	0.868 (1.992)	1.198 (3.187)	-0.459 (-0.881)	-0.613 (-1.079)	0.012 (0.024)	0.037 (1.238)	-0.041 (-0.902)	-0.027 (-0.564)	0.119 (2.049)	-0.042 (-0.799)	--
TTI	-3.614 (-3.208)	1.276 (5.614)	-0.307 (-0.704)	-0.499 (-0.994)	0.517 (1.649)	0.003 (0.355)	0.008 (0.608)	0.005 (0.338)	-0.009 (-0.684)	0.025 (2.891)	--
G	0.014 (0.067)	1.583 (5.591)	-0.768 (-1.381)	0.030 (0.051)	0.074 (0.193)	2.585 (4.147)	-1.269 (-1.214)	-0.389 (-0.343)	1.279 (1.402)		--
G_2	-0.248 (-1.351)	1.849 (5.819)	-1.584 (-2.375)	0.328 (0.368)	0.486 (0.733)	3.406 (12.421)	-2.284 (-2.030)	2.001 (1.614)	1.332 (0.726)		--

[b] deflated by implicit price index.
[c] t-statistics are given in parentheses.

Appendix Table 3: Instantaneous Relationship: Land Value vs Other Variables [Real][a]
Estimates of Model C (coefficients and t-statistics)[c]

Other Vari-ables	b_0	b_1	b_2	b_3	b_4	d_1	d_2	d_3	d_4	d_5	d_6	
EX	4.072	1.635	-0.966	0.041	0.308	-0.579	4.460	-1.779	-7.947	4.562	-2.430	--
	(1.699)	(5.207)	(-1.749)	(0.086)	(1.281)	(-0.338)	(2.079)	(-0.666)	(-3.159)	(1.329)	(-0.954)	
SR_1	0.542	1.461	-0.521	-0.318	0.297	-0.014	-0.067	-0.037	0.103	-0.040	-0.146	--
	(4.104)	(5.438)	(-0.947)	(-0.586)	(1.042)	(-0.526)	(-2.096)	(-1.281)	(2.955)	(-0.833)	(-2.925)	
LR_1	1.294	1.116	-0.214	-0.437	0.391	-0.040	-0.044	-0.112	0.093	-0.053	-0.159	--
	(5.378)	(4.522)	(-0.483)	(-1.146)	(2.058)	(-1.332)	(-1.001)	(-2.334)	(1.772)	(-0.849)	(2.695)	
PI_1	0.293	1.297	-0.519	-0.295	0.088	-0.008	0.002	0.090	-0.099	0.095	0.114	--
	(1.650)	(3.945)	(-0.861)	(-0.518)	(0.333)	(-0.149)	(0.029)	(1.056)	(-0.945)	(0.887)	(1.186)	
CY	-0.461	1.239	-0.886	1.005	-0.544	0.0006	-0.0001	-0.0004	--	--	--	--
	(-1.695)	(4.860)	(-2.094)	(2.225)	(-1.964)	(2.891)	(-0.425)	(-1.586)				
PCCY	-1.125	1.373	-0.827	1.101	-0.724	1.389	-0.332	-0.847	--	--	--	--
	(-2.197)	(5.642)	(-1.890)	(2.364)	(-2.342)	(3.034)	(-0.540)	(1.784)				
RC_1	-2.636	0.743	-0.426	0.276	-0.553	0.257	0.476	0.314	-0.203	0.101	1.268	--
	(-6.155)	(3.347)	(-1.289)	(0.692)	(-2.145)	(1.384)	(1.688)	(1.229)	(-0.729)	(0.282)	(3.762)	
RG_1	-4.196	0.399	-0.263	0.147	-0.641	0.201	0.532	0.626	-0.046	0.129	1.187	0.648
	(-3.662)	(1.072)	(-0.699)	(0.344)	(-2.377)	(0.995)	(1.687)	(1.826)	(-0.175)	(0.391)	(3.795)	(1.334)

...continued

Appendix Table 3 - Continued

Other Variables	b_0	b_1	b_2	b_3	b_4	d_1	d_2	d_3	d_4	d_5	d_6	
RN_1	-2.478	1.295	-0.534	0.292	-0.132	1.125	0.194	0.567	0.231	0.064	1.642	--
	(-3.957)	(5.259)	(-1.146)	(0.569)	(-0.411)	(2.289)	(0.295)	(0.841)	(0.415)	(0.107)	(2.895)	
TG_1	-3.564	0.577	-0.333	0.092	-0.385	0.058	0.666	0.299	-0.193	0.521	0.675	0.574
	(-3.818)	(1.605)	(-0.785)	(0.232)	(-1.624)	(0.306)	(2.407)	(0.932)	(-0.922)	(2.162)	(1.649)	(1.839)
TN_1	-1.871	1.368	-0.520	-0.035	0.197	0.515	0.747	-0.113	-0.177	1.025	0.469	--
	(-3.132)	(4.668)	(-0.989)	(-0.073)	(0.712)	(1.881)	(2.219)	(-0.359)	(-0.613)	(3.346)	(1.218)	
OE_1	-0.491	1.084	-0.661	1.208	-1.098	2.388	-1.365	-1.804	0.747	2.070	-1.199	--
	(-0.655)	(3.069)	(-1.041)	(1.799)	(-2.371)	(2.589)	(-1.489)	(-1.663)	(0.873)	(1.260)	(-0.707)	
TX_1	5.617	1.554	-1.143	0.517	-0.259	-53.313	10.014	-13.632	-4.107	6.117	-45.856	--
	(2.777)	(5.173)	(-2.029)	(0.851)	(-0.729)	(-2.187)	(0.344)	(-0.447)	(-0.133)	(0.203)	(-1.796)	
FOP	0.294	1.280	-1.108	0.779	-0.860	0.005	0.025	-0.037	0.053	-0.041	0.052	--
	(2.098)	(5.279)	(-2.656)	(1.698)	(-2.955)	(0.474)	(1.316)	(-1.567)	(2.085)	(-1.805)	(3.463)	
FIP	0.232	1.404	-0.708	-0.402	0.299	0.041	0.010	-0.069	-0.005	0.157	-0.122	
	(0.463)	(3.994)	(-1.233)	(-0.500)	(0.397)	(1.667)	(0.267)	(-1.907)	(-0.116)	(2.323)	(-1.939)	
TTI	-4.349	1.461	-0.808	0.386	-0.057	0.008	0.010	-0.009	0.023	-0.019	0.027	--
	(-3.554)	(6.045)	(-1.674)	(0.772)	(-0.193)	(1.018)	(0.831)	(-0.627)	(1.507)	(-1.519)	(3.343)	
G	-0.103	1.955	-1.565	0.512	0.067	-0.346	3.222	-2.386	0.429	1.259	--	--
	(-0.727)	(5.310)	(-2.190)	(0.513)	(0.093)	(-0.882)	(7.556)	(-2.373)	(0.374)	(0.952)		
G_1	-0.176	1.907	-1.313	0.023	0.423	-0.022	3.470	-2.340	0.164	2.028	--	--
	(-1.069)	(5.629)	(-1.995)	(0.026)	(0.608)	(-0.066)	(8.418)	(-2.281)	(0.151)	(1.402)		

[a] deflated by consumer price index.
[c] t-statistics are given in parentheses.

Appendix Table 4: Instantaneous Relationship: Land Value vs Other Variables [Real][b]
Estimates of Model C (coefficients and t-statistics)[c]

Other Vari- ables	b_0	b_1	b_2	b_3	b_4	d_1	d_2	d_3	d_4	d_5	d_6	
EX	4.748	1.305	-0.689	0.100	0.183	1.118	1.391	1.774	-6.470	1.013	-2.895	--
	(1.864)	(3.559)	(-1.239)	(0.179)	(0.557)	(0.533)	(0.436)	(0.549)	(-2.039)	(0.267)	(-0.987)	
SR_2	0.473	1.253	-0.450	0.108	0.002	0.010	-0.075	0.021	-0.016	0.064	-0.167	--
	(2.342)	(6.736)	(-1.307)	(0.298)	(0.009)	(0.398)	(-2.209)	(0.656)	(-0.421)	(1.438)	(-4.578)	
LR_2	0.828	1.363	-0.730	0.284	-0.032	-0.009	-0.054	0.017	-0.046	0.031	-0.129	--
	(3.317)	(6.199)	(-1.791)	(0.628)	(-0.112)	(-0.296)	(-1.318)	(0.409)	(-1.112)	(0.731)	(-3.509)	
PI_2	0.598	1.368	-0.783	0.257	-0.208	-0.011	0.019	-0.007	0.037	-0.034	0.117	--
	(2.675)	(6.174)	(-1.949)	(0.537)	(-0.668)	(-0.307)	(0.498)	(-0.192)	(1.002)	(-0.906)	(3.529)	
CY	-0.129	1.062	-0.412	0.608	-0.541	0.0007	-0.0006	-0.000	--	--	--	--
	(-0.596)	(3.811)	(-0.987)	(1.346)	(-1.733)	(3.239)	(-1.842)	(-0.184)				
PCCY	-1.037	1.205	-0.378	0.597	-0.605	1.646	-1.257	-0.119	--	--	--	--
	(-2.137)	(4.259)	(-0.805)	(1.194)	(-1.618)	(2.899)	(-1.768)	(-0.214)				
RC_2	-6.439	1.049	-0.507	0.191	-0.261	0.748	0.446	0.196	-0.076	0.726	0.610	--
	(-3.063)	(3.364)	(-1.053)	(0.329)	(-0.626)	(1.861)	(0.862)	(0.404)	(-0.184)	(1.296)	(1.028)	
RG_2	-10.811	0.854	-0.417	0.142	-0.339	0.522	0.599	0.786	0.225	0.363	1.105	0.614
	(-2.679)	(2.226)	(-0.785)	(0.221)	(-0.729)	(1.018)	(0.963)	(1.204)	(0.409)	(0.557)	(1.521)	(0.891)
RN_2	-1.859	1.550	-0.158	-1.385	1.210	-1.347	3.018	-1.550	-0.422	1.633	0.065	--
	(-0.684)	(4.733)	(-0.232)	(-1.414)	(1.842)	(-1.036)	(1.829)	(-1.169)	(-0.434)	(1.630)	(0.081)	
TG_2	-5.518	1.377	-0.951	0.452	-0.234	0.413	0.013	0.407	-0.064	0.740	-0.015	0.567
	(-2.016)	(3.929)	(-1.655)	(0.768)	(-0.627)	(1.339)	(0.039)	(1.317)	(-0.245)	(2.502)	(-0.041)	(1.877)

...continued

Appendix Table 4 - Continued

Other Variables	b_0	b_1	b_2	b_3	b_4	d_1	d_2	d_3	d_4	d_5	d_6	
TN_2	-1.596 (-0.502)	1.739 (4.984)	-0.870 (-1.199)	-0.017 (-0.023)	0.281 (0.524)	0.346 (0.584)	0.016 (0.029)	0.182 (0.425)	-0.194 (-0.441)	0.673 (1.309)	0.161 (0.316)	--
OE_2	-2.777 (-1.752)	0.982 (2.186)	-0.722 (-1.252)	0.319 (0.462)	-0.305 (-0.602)	1.797 (2.070)	-0.189 (-0.201)	0.157 (0.176)	0.097 (0.102)	1.148 (0.957)	0.779 (0.742)	--
TX_2	4.599 (3.434)	1.129 (3.792)	-0.496 (-0.999)	-0.333 (-0.600)	0.137 (0.397)	0.116 (0.009)	-13.554 (-0.836)	1.360 (0.079)	-2.354 (-0.136)	-3.852 (-0.231)	-23.398 (-1.694)	--
FOP	0.806 (2.927)	0.999 (2.919)	-0.326 (-0.603)	-0.285 (-0.510)	-0.233 (-0.601)	0.003 (0.212)	0.0001 (0.003)	0.008 (0.216)	0.005 (0.131)	-0.009 (-0.306)	0.036 (1.789)	--
FIP	0.824 (2.035)	1.142 (3.261)	-0.537 (-1.106)	-0.198 (-0.337)	-0.088 (-0.189)	0.045 (1.574)	-0.021 (-0.461)	-0.027 (-0.625)	-0.027 (-0.600)	0.119 (2.215)	-0.062 (-1.229)	
TTI	-4.530 (-3.408)	1.123 (4.414)	0.024 (0.048)	-0.696 (-1.349)	0.552 (1.800)	0.010 (1.221)	-0.010 (-0.756)	0.021 (1.238)	0.0006 (0.035)	-0.008 (-0.655)	0.028 (3.168)	--
G	0.044 (0.198)	1.596 (5.495)	-0.815 (-1.422)	-0.039 (-0.063)	0.179 (0.428)	-0.492 (-0.734)	2.955 (3.634)	-1.338 (-1.244)	-0.513 (-0.438)	1.529 (1.538)	--	--
G_2	-0.269 (-1.383)	1.811 (5.370)	-1.482 (-2.065)	0.215 (0.226)	0.542 (0.778)	0.148 (0.538)	3.331 (10.510)	-2.143 (-1.793)	1.821 (1.381)	1.491 (0.774)	--	--

[b] deflated by implicit price index.
[c] t-statistics are given in parentheses.