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AN UPDATING WITH COMPARISONS

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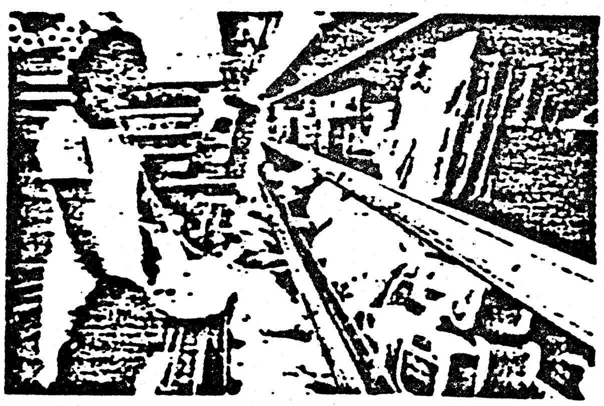

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ABSTRACT

This paper reexamines four econometric models of the U.S. farmland market to test their validity over different and more recent time periods. Updating these models appears not to be fruitful. If econometric analysis is to play a role in analysis of the farmland market, it will probably be effective only in local areas where productive factors and responses to them are reasonably homogeneous, rather than within a national aggregated market for U.S. farmland.

Key words: Econometric models, U.S. farmland prices, capital gains, net returns.

PREFACE

This study was completed under Research Agreement No. 58-3J23-0-0155X between the National Economics Division, Economic Research Service, U.S. Department of Agriculture, and the University of Missouri-Columbia. The enclosed report is one of a series of reports; forthcoming reports will include: (1) A Critique of the Literature on U.S. Farmland Values, (2) A Comparison of Cash Rents and Land Values for Selected Farming Regions of the United States, (3) Imputing Returns to Production Assets in Ten U.S. Farm Production Regions, and (4) The Value of Agricultural Land in the United States: Some Thoughts and Conclusions.

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SUMMARY

The authors' re-examine four econometric models of the farmland market to see whether conclusions by Pope and others are valid over different, varied, and more recent time periods. The four econometric models were:

1. Tweeten and Martin's five-equation model.
2. Herdt and Cochrane's two-stage least-square model.
3. Reynolds and Timmon's recursive model.
4. Klinefelters single-equation model.

None of the econometric models has proved valid in meeting the test of different, varied and more recent time periods.

The Tweeten and Martin's five-equation model attempts to explain the process which generates farmland prices. Data originally used covered the period 1923-63. The analysis was repeated for 1946-72 and subsequently for 1944-78.

Herdt and Cochrane developed a two-equation model, as did Reynolds and Timmons, but used the orthodox supply-demand framework rather than a recursive system.

The Reynolds and Timmons model uses time series data, and hypothesized that the price of farmland is determined by the number of farmland transfers and other variables.

Klinefelter used a single-equation model estimated by least-squares. This model is confined to Illinois only but can be extrapolated for general application to the U.S. market. Pope and others modified this model in comparing econometric models of the farmland market.

Investigation reveals that the various authors of the econometric models agree on the theoretical framework used to analyze the farmland

market. The authors use the U.S.D.A. Balance Sheet of Agriculture in examining models and variables. The process served to confirm the importance of the variables selected.

Techniques examined allowed comparison of ordinary least-squares (OLS), autoregressive least-squares (ALS), and recursive least-squares (RLS) methods. Technique selection must be based upon the end-use of the model: Prediction verses structural estimation.

INTRODUCTION

In the past, several researchers have formulated econometric models of the U.S. agricultural land market, usually with the object in view of explaining increases in land values. The models could generally be termed successful in terms of the fit to the observed data on land "prices." 1/ The data are almost exclusively presented in time-series form, and proxies for required data are often employed. Time spans and specification of models employed differ from analyst to analyst.

Although the literature contains several competing models of the agricultural land market, there has been only one comprehensive attempt to compare the performance of the various models over similar time periods. Pope and others [8] found that when models were estimated for a time span different from the original period of analysis, their performance in terms of expected sign patterns and significance levels of coefficients fell off considerably. 2/ Pope, and others, concluded that:

> "These results suggest that the model specifications do not reflect accurately enough the relevant structural changes and other characteristics of the farmland market." 3/

This paper reexamines the four models which Pope and others updated, to see whether Pope's conclusions are valid over different, more recent, time periods. Further, the sample will be broken into sub-periods to see if insights into the structural changes referred to by Pope can be obtained. This study will also test the influence of capital gains on prices, and use data derived from the

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1/ One of the problems facing researchers working on the farmland market is that data are not available on the selling price of land. The USDA collects data on value of farmland as estimated by its experts, and this is available per acre of land or in index form. See USDA ESCS [13]. This point will be taken up in the concluding comments.

2/ The underscored numbers in brackets refers to items in the References section.

3/ Pope and others [8], p. 115.

Balance Sheet of Agriculture to replace the cruder proxies of earlier models. Other than these changes, models and techniques are kept as close to the original models as is possible. 4/

This study will not contain tests of the predictive power of the models outside the range of the sample. Pope and others did consider forecasting, and found that "simple" models, such as a Box-Jenkins model, performed better than sophisticated econometric models. There have been proposals to consider simple models of the farmland market to explain price changes. This study will close by proposing one such model.

ECONOMETRIC MODELS EXAMINED

The study will commence by looking again at the four econometric models examined by Pope and others in the following order:

1. Tweeten and Martin's five equation model
2. Herdt and Cochrane's 2SLS model
3. Reynolds and Timmons' recursive model
4. Klinefelter's single equation model

Tweeten and Martin [10]

In the May 1966 Journal of Farm Economics, Tweeten and Martin proposed a farmland model that was "suggestive of directions and methodology rather than definitive." 5/ Their study, which was intended to predict U.S. farm real estate price variation, contains the most sophisticated and complex model to be presented to date. It is comprised of a five-equation recursive system, with individual equations estimated by both ordinary least squares (OLS) and autoregressive least squares (ALS) techniques. Each equation includes the dependent variable lagged one period as an explanatory variable. This permits the equations to be interpreted as a partial adjustment or distributed lag model.

4/ Assistance was provided by R. A. Kramer, who supplied his data set.
5/ Tweeten and Martin [10], p. 392.

The model, which is outlined in table 1, sets out to explain the process which generates land prices. The culmination of the process is the land price equation (equation 1, table 1), wherein land prices are made dependent on three endogenous and three exogenous variables. Of the endogenous variables, two, namely farm number and farm transfers, are themselves determined by exogenous variables, in equations 4 and 5, which stand alone. The third, land-in-farms, depends, in turn, on a fourth endogenous variable, cropland, which is determined by equation 3. Each variable used in the analysis is defined in table 1: the expected sign patterns are given in the tables of results. 6/

The model was originally estimated from data for the period 1923-63, with a dummy varible for the war years. Equations 3, 4 and 5 were estimated using both OLS and ALS. Values of the coefficient of determination and the Durbin-Watson statistic were used to help decide whether the OLS or the ALS equation would be used to predict the estimates of endogenous variables to be used in in equations 1 and 2. Equations 1 and 2 were than estimated using OLS, ALS, and recursive least squares (RLS). Pope and others repeated the analysis for the period 1946-72, but used only the version of each equation which Tweeten and Martin had juged "best." In the discussion below, the results of Tweeten and Martin, and Pope and others will be compared to new estimates of the equations for data covering the period 1944-78. Equations will be presented in the reverse order to that in the Tweeten and Martin paper, starting with equation 5 and ending with equation 1.

With one exception, variables used for the new estimates follow the definitions given in table 1. That exception is expected capital gains, where

---

6/ There will be no attempt here to explain the theory behind the relationships expected from the models. A review of the theory behind the models is given in Doll and Widdows [1]. The form of the model as it appears here was the culmination of a sequence of attempts to model the farmland market in which Tweeten was involved. See Heady and Tweeten [2] and Tweeten and Nelson [11].

TABLE 1 - TWEETEN AND MARTIN'S MODEL: EQUATIONS AND VARIABLES

Equations
(Variables to the left of the semicolon are endogeneous)

(1)	Land price	$P_t = f(L_t, A_t, T_t\ F_{t-1}, r_{t-1}, P_{t-1}$
(2)	Land-in-farms	$L_t = f(C_t; F_{t-1}, L_{rt}, E_t, L_{t-1})$
(3)	Cropland	$C_t = f(F_{t-1}, L_{r*}, T_2, C_{t-1})$
(4)	Farm numbers	$A_t = f(JX_{t-1}, C_{*gt-1}, S_t, T_2, A_{t-1}$
(5)	Farm transfers	$T_t = f(JX_{t-1}, C_{gt-1}, S_t, T_2, T_{t-1})$

Variables
(Annual U.S. data for 1923-1963)

A is the number of farms, in thousands.
C is cropland used for crops, in million acres.
C*g is capital gains on farm real estate, $C^*_{gt-1} = .5C'_{gt-1} + .33C'_{gt-2} + .17C'_{gt-3}$ where C'_g is capital gain.
E is employment, national nonfarm, in millions.
F is net farm income, in billion dollars (gross farm income less production expenses).
JX is the ratio of average earnings per employed factory workers, Y_n, to the average income per farm worker, Y_w, modified by the nonfarm employment rate, U;

$$JX_{t-1} = \frac{Y_{nt-1}}{Y_{wt-1}}(1 - SU_{t-1})$$

L_r is land removed from production by government programs, in million acres.
L is land in farms, in million acres.
P is the price index of U.S. farm real estate (land and buildings) per acre (1957-1959 = 100) deflated by the wholesale price index (1957-1959 = 100). The average per acre value of real estate was \$104 in the 1957-59 period, hence one index point in P is equal to \$1.04 (1957-1959 dollars).
r is the rate of return on nonfarm investment: Standard and Poor's data on common stock dividend divided by market value of stock, in percent.
S is the stock of machinery, beginning year, in million 1957-1959 dollars.
T is transfers of farm real estate per 1,000 farms.
T_2 is a dummy variable equal to 1 from 1942 to 1948 and to 0 elsewhere.

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new USDA data are employed. 7/ In all equations, lag structures, autoregressive processes, and jointly-determined variables are as specified by Tweeten and Martin. Autoregressive processes are lagged one year only.

Table 2 presents results of runs of Tweeten and Martin's equation 5--the transfer equation. Transfers of land is one of the proxies for the quantity of land offered for sale in the current year; together with transfers, land-in-farms and farm numbers, A, will be used as proxies in the land price equation. A data series of sales of land measured in terms of acres and weighted by quality for those acres sold is not available. Tweeten and Martin's original estimates, the coefficients on all but one variable had the expected signs, and all were significant at the 95 percent level. The coefficient on the variable JX, representing the ratio of farm to nonfarm earnings, was of dubious sign. Pope and others found that the coefficient of JX had the expected positive sign where a different time period was used. This finding was confirmed by the new estimates but, in these, the sign on expected capital gain coefficient is no longer that expected by Tweeten and Martin. While this conflicts with the earlier estimates, it does not necessarily create a problem for the theory behind the equation, because of an ambiguity in the discussion by Tweeten and Martin. They make cases for both positive and negative signs on the coefficients of the C^*_g and JX variables, and resolved the issue apparently by appeal to the empirical results. 8/ According to their discussion, the positive sign on the

7/ The data appear in the Balance Sheet of the Farming Sector, which is published on a regular basis by the USDA ERS. See USDA ERS [12] for a recent example. A convenient summary of these figures and other recent agricultural financial statistics is Melichar and Waldheger [7]. Tweeten and Martin define capital gains as the incremental change in per acre value of farmland less capital improvements. This formulation is retained by Pope and others. The USDA ERS broadened the definition of capital gains to include capital gains on physical assets other than real estate, financial assets and debt. Besides providing a more comprehensive calculation of capital gains, the USDA series is a change from the use of changes in lagged values of farmland to explain current value of farmland. Not surprisingly, the Tweeten and Martin series provided "good" partial coefficients, and created much interest in the role of capital gains in explaining prices of farmland. For an extended discussion of capital gains as defined by Tweeten and Martin, see Tweeten and Nelson [11], pp. 1-13.

8/ Tweeten and Martin [10]. p. 381 and p. 387.

TABLE 2 - TWEETEN AND MARTIN EQUATION 5: THE TRANSFER EQUATION

Period	Method	Constant	+[d] JXt-1	- CGt-1	- St	+ Tt-1	+ T2	R^2	DW	B
1923-63[a]	OLS	51.16	-.028	-.67	-00068	.32	11.58	.87	1.72	
			(1.897)	(3.16)	(2.132)	(2.14)	(4.08)			
1946-72[b]	OLS	8.37	.137	-.033	-.0006	.839		.89	1.10	
			(.367)	(1.43)	(.867)	(7.936)				
1944-78[c]	OLS	17.94	.079	.00028	-.0002	.664		.84	1.46	
			(.061)	(.00012)	(.00007)	(.107)				
1944-78	ALS	19.11	.064	.0003	-.0002	.630		.80		
			(.066)e	(.0001)	(.00008)	(1.117)				
1944-60	OLS	57.76	.0047	.0006	-.0015	.049		.95	1.39	
			(.060)	(.0002)	(.0003)	(.179)				
1944-60	ALS	62.07	-.0148	.0006	-.0016	-.021		.93		-.259
			(.062)	(.0002)	(.0003)	(.167)				(.234)
1961-78	OLS	20.87	.069	.0002	-.00012	.499		.53	1.11	
			(.097)	(.00014)	(.00008	(.269)				
1961-78	ALS	25.38	.027	.0002	-.00015	.321		.44		-.430
			(1.09)	(.00011)	(.00008	(.266)				(.213)

a. Original Tweeten and Martin estimates.

b. Pope and others estimates.

c. (and remaining versions) New estimates.

d. Expected signs are from Tweeten and Martin's original work.

e. In this and all subsequent tables, the figures in parenthesis are the standard errors of the regression coefficients.

coefficient of the C*g variable over the 1944-78 period would support the idea that capital gains encouraged farmers to stay in farming to gain appreciation of property values.

The new estimates included estimates for two sub-periods of the 1944-78 period. Such estimates might provide additional evidence on the structure of the farmland market; sub-periods have been studied for all four econometric models examined. Here, equation 5 provides a much better fit over 1944-60 data than it does over 1961-78 data. Generally speaking, results for the 1944-78 period have consistent sign patterns.

Only the results of the OLS run of equation 5 were presented by Tweeten and Martin, because they judged $\hat{B}=0$ to be the best estimate of the autoregression parameter. In the new estimate too, there is no evidence that the ALS equation is better than the OLS equation, so the OLS estimates of transfers, $\hat{T}$, are carried forward to equation 1.

The next equation in the 5-equation system, the farm numbers equation, is similar to the transfer equation in specification. Tweeten and Martin claim, on the basis of magnitude of coefficients, that this does not necessarily make farm numbers (A) a linear function of the transfers (T) equation. The results of various runs of the farm numbers equation (shown in Table 3) indicate some problems with the equation, because signs on coefficients change both with the period and technique used for the run. The relationship between farm numbers and capital gains is particularly confused. Pope and others and the new estimates for 1944-78 suggest a positive relationship, while the original estimates and the new short-period estimates suggests a negative relationship. In general, the equations show high values for the coefficients of determination but weakly-significant individual coefficients; this suggests that multicollinearity is present. In addition, Durbin-Watson statistics are frequently outside of the

TABLE 3 - TWEETEN AND MARTIN EQUATION 4: THE FARM NUMBERS EQUATION

Period	Method	Constant	+ JXt-1 [d]	- CGt-1	- St	+ At-1	T2	R^2	DW	B
1923-63[a]	OLS	418.46	.11	9.72	-.17	.94	49.92	.998	.90	
			(1.05)	(4.86)	(3.72)	(38.75)	(1.96)			
1923-63[a]	ALS	-215.96	-.11	-4.36	.002	1.01	3.96	.999	1.60	.84
			.53	(1.87)	(.422)	(26.58)	(.21)			(6.23)
1946-72[b]	OLS	343.48	29.125	.091	-.035	.93		.98	2.81	
			(1.385)	(.071)	(.868)	(21.346)				
1944-78[c]	OLS	89.72	.0018	0[e]	0	-.00014		.97	1.45	
			(.0008)			(.000014)				
1944-78	ALS	46.50	1.96	.0021	-.00009	.98		.995		.35
			(1.27)	(.0029)	(0022)	(.023)				(.16)
1944-60	OLS	2,869.30	.0047	0	0	0		.65	1.92	
			(.002)							
1944-60	ALS	2,250.68	2.711	-.0079	-.0376	.666		.98		.159
			(3.30)	(.011)	-.0153)	(.147)				(.239)
1961-78	OLS	232.60	.0029	0	0	0		.99	1.21	
			(.001							
1961-78	ALS	181.37	.399	-.0001	.00042	.919		.99		-.410
			(3.67)	(.0003)	(.00004)	(.017)				(.215)

a. Original Tweeten and Martin estimates.

b. Pope and others estimates.

c. (and remaining versions) New estimates.

d. Expected signs are from Tweeten and Martin's original work.

e. In this and all subsequent tables, the figures in parenthesis are the standard errors of the regression coefficients.

TABLE 4 - TWEETEN AND MARTIN EQUATION 3: THE CROPLAND EQUATION

Period	Method	Constant	+ Ft-1	- Lrt	+ Ct-1	T2	R^2	DW	B
1923-63[a]	OLS	180.73	.38	-.44	.51	-3.13	.91	1.51	
			(1.73)	(5.92)	(5.13)	(1.22)			
1923-63[a]	ALS	38.36	.88	-1.036	.29	-3.47	.84	2.10	.86
			(1.99)	(6.66)	(1.05)	(.87)			(4.97)
9146-72[b]	OLS	111.16	2.890	-.298	.56		.94	1.88	
			(3.433)	(1.753)	(3.05)				
1944-78	OLS	142.36	.00037	-.353	.57		.90	1.87	
			(.00036)	(.149)	(.144)				
1944-78	ALS	143.05	.0004	-.355	.57		.90		.0034
				(1.49)	(1.43)				(.169)
1944-60	OLS	2.00	.0019	.176	.912		.86	2.07	
			(.0010)	(.284)	(.225)				
1944-60	ALS	-21.97	.0019	.243	.982		.90		.191
			(.0084)	(.249)	(.200)				(.238)
1961-78	OLS	260.05	.00095	-.414	.161		.89	1.69	
			(.0005)	(.169)	(.170)				
1961-78	ALS	272.14	.00095	-.432	.124		.88		-.084
			(.0005)	(.160)	(.167)				(.235)

a. Original Tweeten and Martin estimates.

b. Pope and others estimates. Remaining equations are new estimates.

Period	Method	Constant	+ C_t	+ F_{t-1}	+ Lr_t	− E_t	+ L_{t-1}	R^2	DW	B
1923-63[a]	OLS	-134.37	.41	.80	.36	-.67	1.00	.994	.87	
			(2.20)	(2.37)	(1.96)	(2.75)	(38.31)			
1923-63	RLS	-83.21	.28	.79	.25	-.64	1.00	.994	.72	
			(.89)	(2.21)	(.93)	(2.49)	(34.19)			
1923-63	ALS	23.40	.39	.85	.26	-.32	.96	.996	2.21	.74
			(1.85)	(1.87)	(1.28)	(.70)	(9.29)			(3.59)
1946-72	OLS	986.29	.15	-7.11	-.481	-1.38	.257	.66	1.99	
			(.219)	(1.73)	(.817)	(3.34)	(1.636)			
1946-72	RLS	1,508.5	-1.9	.65	-.212	-1.106	.314			
			(1.33)	(1.04)	(1.815)	(2.494)	(2.023)			
1944-78	OLS	754.05	-4.19	-.0019	-.667	-.82	.536			
			(.446)	(.0013)	(.385)	(.53)	(1.34)			
1944-78	RLS	724.42	-.453	-.002	-.733	-.659	.568	.82	2.65	
			(.687)	(.0012)	(.607)	(.471)	(.127)			
1944-78	ALS	659.21	-.527	-.0015	-.752	-.712	.64	.91		.34
			(.360)	(.001)	(.315)	(.421)	(.105)			(.159)
1944-78[b]	ARLS[b]	652.24	-.538	-.002	-.813	-.516	.670	.90		.31
			(.643)	(.001)	(.575)	(.399)	(.104)			(1.61)
1944-60	OLS	1,245.14	-1.25	-.0012	-1.81	.721	.296	.50	2.60	
			(1.08)	(.005)	(.976)	(1.198)	(.270)			
1944-60	RLS	1,774.1	-2.59	.0028	-2.81	.981	.184	.50		
			(1.49)	(.0062)	(1.28)	(1.30)	(.287)			
1944-60	ALS	1,073.44	-1.226	-0.0002	-1.854	.640	.428	.71		.34
			(.877)	(.004)	(.76)	(1.029)	(.216)			(.228)
1944-60	ARLS	1,606.34	-2.471	.0036	-2.732	.728	.295	.77		.35
			(1.083)	(.0042)	(.859)	(.907)	(.205)			(.227)
1961-78	OLS	868.53	-.0033	-.007	-.199	-1.731	.350	.89	2.55	
			(.474)	(.001)	(.329)	(.896)	(.260)			
1961-78	RLS	496.57	1.39	-.0019	.539	-1.909	.294	.82		
			(2.62)	(.0027)	(1.39)	(1.231)	(.363)			
1961-78	ALS	699.90	-.099	-.0007	-.254	-1.335	.496	.94		.32
			(.393)	(.0009)	(.303)	(.815)	(.234)			(.22)
1961-78	ARLS	417.93	1.004	-.0016	.352	-1.487	.445	.94		.29
			(1.865)	(.0017)	(1.045)	(.824)	(.235)			(.225)

a. 1923-63 versions are from Tweeten and Martin, 1946-72 are from Pope and others, remaining runs are new estimates.

b. ARLS is recursive least squres with a one-period autoregressive scheme.

TABLE 6 - TWEETEN AND MARTIN EQUATION 1: THE LAND PRICE EQUATION

Period	Method	Constant	− Lt	− Tt	− At	+ Ft-1	− Rt-1	+ Rt-1	R^2	DW	B
1963-63[a]	OLS	89.5	-.37	-.23	-.0007	.58	-1.56	.77	.95	1.53	
			(1.892)	(2.49)	(1.164)	(3.04)	(3.28)	(7.09)			
1923-63	RLS	88.58	-.033	-.41	-.0011	.58	-1.63	.77	.96	1.61	
			(1.91)	(4.06)	(.514)	(3.23)	(2.90)	(8.83)			
1923-63	ALS	14.77	-.146	-.37	-.0068	1.68	-.72	.39	.92	1.84	.95
			(1.35)	(3.54)	(.830)	(3.81)	(1.25)	(1.96)			(8.08)
1946-72	OLS	14.62	.025	.113	-.009	1.147	-1.94	.89	.99	2.26	
			(.851)	(.544)	(2.36)	(1.893)	(1.21)	(7.33)			
1946-72	RLS	41.89	-.011	-.298	-.004	1.184	1.567	.94			
			(.302)	(1.078)	(1.011)	(1.679)	(.882)	(8.52)			
1944-78	OLS	-2.56	.0017	.0098	2.038	0[b]	-.069	-2.48	.93		
			(.0022)	(.0122)	(1.29)		(.093)	(.357)			
1944-78	RLS	0.84	-.0007	.0008	1.12	0	-.019	-.044	.92		
			(.0013)	(.006)	(.49)		(.047)	(.217)			
1944-78	ALS	2.21	-.0014	-.0077	-.00002	0	.048	.34	.94		.163
			(.0009)	(.004)	(.000005)		(.031)	(.17)			(1.67)
1944-78	ARLS	1.39	-.0012	.0015	1.002	0	.0004	-.054	.95		.079
			(.001)	(.005)	(.299)		(.033)	(.187)			(.168)
1944-60	OLS	2.11	.0003	.0087	1.736	.00004	-.033	.499	.74	2.63	
			(.0014)	(.014)	(1.070)	(.00006)	(.119)	(.649)			
1944-60	RLS	-3.24	.0013	.013	1.61	.00004	.054	.470	.65		
			(.0025)	(.015)	(.77)	(.00005)	(1.82)	(.542)			
1944-60	ALS	1.24	-.0005	-0.14	.00013	0	.166	-.337	.78		.282
			(.0014)	(.006)	(.00011)		(1.56)	(2.89)			(.233)
1944-60	ARLS	2.43	-.0011	-.006	.616	0	.0044	-.372	.63		.133
			(.0025)	(.017)	(2.10)		(.241)	(.340)			(2.40)
1961-78	OLS	0.84	.0002	.001	1.315	0	.0012	-2.92	.98	1.61	
			(.0006)	(.033)	(10.31)		(0.48)	(9.63)			
1961-78	RLS	-2.05	.0017	.0002	.341	0	.0039	.815	.97		
			(.0013)	(.008)	(1.126)		(.0022)	(1.16)			
1961-78	ALS	0.84	-.0004	-.003	-.0008	0	-.005	.934	.98		.019
			(.001)	(.003)	(.0001)		(.014)	(.162)			(.236)
1961-78	ARLS	-2.43	.0019	.0024	.515	0	-.0011	.776	.96		.446
			(.0007)	(.0036)	(2.47)		(.011)	(2.44)			(2.11)

a. 1923-63 equations are Tweeten and Martin's original estimates; 1946-72 are Pope and others estimates, while 1944-78 and sub-period estimates are new.

acceptable range. This equation thus appears to be a weak link in the chain. Tweeten and Martin preferred the OLS equation for estimating $\hat{A}$ for use in equation 1. For the new estimates, the ALS version is used, because of its goodness of fit, correct sign patterns, and significant autoregression parameter.

Results of estimation of equation 3, the cropland equation, are shown in table 4. For this equation, expected sign patterns persist through all the long-period runs. 9/ The relationship between net farm income and cropland is, however, only weakly significant in all versions of the equation. In both the original and the new runs, the OLS verions of the equation is used to predict cropland for the land-in-farms equation, because the ALS version does not improve noticeably on OLS results.

Tweeten and Martin reported some success with their land-in-farms equations; the five independent variables accounted for 99 percent of the variation in the dependent variable, with all coefficients having the correct sign and all but one (Lr) being significant at the 95 percent level. As table 5 shows, Pope and others findings were not so favorable. Only two variables (E and L_{t-1}) have coefficients that maintain their expected signs, and the fit of the equation is substantially poorer. This finding is repeated for the 1944-78 estimates, though the fit is improved somewhat. The equation performs better over the 1961-78 sub-period, especially under ALS technique. Tweeten and Martin preferred the ALS equation for use in estimating land-in-farms for equation 1, since the autoregression parameter was highly significant and the Durbin-Watson statistic was insignificant. At the same time, they regretted not having estimated an autoregressive version of the recursive equation. This was done for the new runs, but it was not found to improve on the ordinary ALS version; thus, the latter was used to estimate $\hat{L}$ in the new runs.

9/ Only in the sub-period 1944-60 does an unexpected sign emerge for the relationships between cropland and land removed from production by the Government.

Tweeten and Martin's "composite hypothesis explaning the process through which land prices materialize" 10/ culminates in equation 1, where an attempt is made to use the aforementioned endogenous "quantity" variables (L, A, T) together with net farm income, rates of return on nonfarm investment and lagged prices, to explain the price index of U.S. farm real estate. 11/ Tweeten and Martin found their equation to have a good fit and expected signs, with all coefficients significant at at least the 10 percent level. They observed that the significance of the coefficients on farm numbers (A) variable fell in the recursive equation and suggested that this might be due to inadequate specification of the farm numbers equation. 12/ The following reservations were also expressed on the basis of the significant autoregression parameter in the ALS version:

> "An autocorrelated error structure would seldom arise if the data were error free and all relevant variables were included in the appropriate algebraic form." 13/

The price equation does not stand the test of time period changes, as table 6 shows. Pope and others 1946-72 estimates produced sign changes for all but three coefficients (A, F_{t-1} and P_{t-1}); while in the new runs, 1944-78, coefficients of all variables were subject to sign changes. As in the original, the new estimates show significant autoregression parameters; in fact the ALS version is the "best" of the 1944-78 versions in the sense that only one coefficient (R) has an unexpected sign. In the new estimates, most individual coefficients have weak levels of significance, indicating, in combination with the high R^2's, that there may be multi-collinearity problems.

10/ Tweeten and Martin [10], p. 379.
11/ They in fact presented three versions of the price equations, one excluding the r variable, and one having A lagged one period. This study follows Pope in using the version with the r and A_t.
12/ This equation was referred to above as the weak link in the chain in view of its poor performance on the new runs.
13/ Tweeten and Martin [10], p. 384.

The model performs differently over the two sub-periods, 1944-60 and 1961-78. The 1961-78 ALS version supports Tweeten and Martin's hypotheses regarding signs, and fits the data well (though again signs of multi-collinearity exist). The 1944-60 version generally perform badly and have different sign patterns to the 1961-78 runs. It would seem then that the equation, and therefore the model as a whole, is somewhat unstable, and not a durable specification of the farmland market. 14/ The two sub-period estimates suggest that part of the problem may be that the structure of the land market is subject to short-period changes which might affect the longer-period performance of the model.

When summarizing their findings, Tweeten and Martin pointed out that their econometric model is only a subset of many possible explanations of the farmland market. They reviewed the techniques used, and were not able to recommend any one in particular, since the merits of each were offset by their problems. Thus OLS was recommended for its directness but criticized for its least squares bias. RLS reduced the least squares bias, but in a 5-equation system, tends to compound any specification errors present. ALS appeared to improve estimates of the coefficients but created problems with the weakness of significance of variables. All of these problems carried through to the new runs; no one method can be recommended over the others.

In summary, the tests we have used here suggest that the 5-equation model has not stood the test of time as a prescription for the farmland market and an explanation of farmland price changes. Of the individual equations, only the cropland equation has shown stability over time. The variability found in the other equations implies that specification errors could accumulate in this recursive system. Financial-type variables caused the major problems in

14/ Tweeten and Martin tried several additional variables in equation 1, and even a time trend, but without improving on the model shown.

individual equations. Coefficients on capital gains, rates of interest and earnings variables did not maintain either their levels of significance or (often) their signs as compared to the original estimates. Variables such as stocks of machinery or land in farms, which are more directly measured have been more successful. Evidence from the sub-period estimates suggest that financial variables were most volatile in the late 40's and the 50's; perhaps the higher inflation and interest rates of recent years are forcing farmers to pay more heed to these variables. At any rate, the model does seem to produce more consistent estimates over the shorter (1961-78) period.

If the 5-equation model has proved somewhat too elaborate a scheme for analysis of the farmland market, a way to proceed might be to simplify the model by reducing the number of equations in the system. Reynolds and Timmons presented a two-equation recursive model of the farmland market, which will now be discussed.

<u>Reynolds and Timmons [9]</u>

Like Tweeten and Martin, Reynolds and Timmons establish what they believe are the major factors affecting value of farmland, and develop a method to test the importance of the relevant variables. Time series data are used, and a recursive two-equation system combined with OLS is used to estimate parameters. Unlike some other analysts, they also attempt to estimate their model using cross-section data, but with only limited success.

Reynolds and Timmons hypothesize that the price of farmland is determined by the number of farmland transfers and certain exogenous variables as follows:

$$V = f(T; NFI, GP, Cg, r, A)$$

where definitions of variables are in table 7. The number of transfers is itself determined by the following variables:

$$T = g(Cg, F/NF, TE, D/E, N)$$

TABLE 7 - DEFINITIONS OF VARIABLES USED BY REYNOLDS AND TIMMONS

A	Change in the average size of farm (acres)
b	Intercept
C_g	Expected capital gains (dollars/acre).
CP	Conservation payments (dollars/acre)
D/E	Ratio of debt to equity (percent)
D/V_1	Ratio of debt to value of farmland (percent)
E(F/NF)	Expected ratio of farm to nonfarm earnings (percent)
GFI	Gross income (dollars/acre)
GP	Government payments tied to land (dollars/acre)
GPL	Government payments for land diversion (dollars/acre)
i	Farm mortgage interest rate (percent)
La	Labor (hours/acre)
N	Change in number of farms (1,000 farms)
NFI	Expected net farm income (dollar/acre)
PD	Nonfarm population censity (people/square mile)
r	Rate of return on common stock (percentage)
$\underline{T}$	Voluntary transfers of farmland (1,000 farms)
T	Predicted voluntary transfers of farmland (1,000 farms)
$\underline{Tv}$	Voluntary transfers of farmland per 1,000 farms
Tv	Predicted voluntary transfers of farmland per 1,000 farms
V_1	Value of farmland (dollar/acre)
V_2	Value of farmland without farm buildings (dollars/acre)

where TE is technology, and is measured by the (weak) proxy, hours of labor per acres, L_a. The equations bear some similarity to equations 5 and 1 of Tweeten and Martin. Noticeably absent are lagged values of dependent variables from the right hand side, while government payments to land were added. For the estimation of equations, the expected values for each series were assumed to be represented by a three-year weighted average of past values for each of the series, as follows:

$$E(X_t) = \sum_{i=1}^{m} wiX_{t+1} -i / \sum_{i=1}^{m} wi$$

where:

$$wi = m + 1 - i$$
$$m = 3$$

This was lagged one year. This is similar to Tweeten and Martin's representation of exceptations, and is a form used in the remainder of the econometric models examined. V, NFI, CP, CPL, GP and Cg were deflated by the index of prices paid by farmers for items used in living and production (P).

In table 8, results of two formulations of the transfer equation are given. Both equations performed well in the original runs, and of the two, equation 13 was selected for the prediction of transfers because it explained slightly more of variation in transfers than did equation 12, while providing individual regression coefficients with higher significance levels. Pope and others selected equation 13 for their update, but reported three sign changes compared to the original estimates. The new estimates were a little more successful than Pope's. Equations 12 and 13 both showed a sign change on the coefficient of the D/E variable when compared to the original estimates while equation 13 showed a sign change on the coefficient of the average size of farms (A) variable. Both equations explained 95 percent of variation in transfers. Performance of equation 13 over the 1961-78 period is not as good; of particular interest is instability of the capital gains variable—this did

TABLE 8 - TWEETEN AND MARTIN EQUATTION 1: THE LAND PRICE EQUATION

Equation	Period	Constant	–[d] D/E	+ La	+ E(F/NF)	+ N	+ Cg	– A	R^2	DW
12	1933-65[a]	-40.88	-7.10	14.35	1.96	0.11	2.72		.98	1.83
			(1.14)	1.00	(0.44)	(0.06)	(0.82)			
13	1933-65[a]	-11.23	-7.36	13.76	1.58		4.86	-3.35	.98	1.84
			(1.04)	(1.13)	(0.47)		(1.52)	(1.53)		
13	1946-72[b]	-309.94	19.69	34.82	-7.70		-1.50	-.51		
			(2.99)	(8.64)	(.08)		(.41)	(1.33)		
12	1944-78[c]	-359.75	1.57	.016	186.18	30.24	.002		.95	1.18
			(0.35)	(.008)	(75.81)	(38.12)	(.0005)			
13	1944-78	-387.40	1.26	.025	221.9		.002	2.18	.95	1.19
			(0.51)	(.007)	(59.7)		(.0006)	(.614)		
12	1944-60	-384.3	1.49	0.011	178.3	49.09	.004		.95	1.51
			(1.23)	(.011)	(159.1)	(53.40)	(.001)			
13	1944-60	-244.0	1.03	0.02	226.7		.004	-0.097	.95	1.42
			(1.24)	(.01)	(175.6)		(.001)	(1.23)		
12	1961-78	-38.00	-.019	.003	145.5	15.24	-.0001		.36	.88
			(.626)	(.023)	(144.1)	(105.55)	(.0006)			
13	1961-78	641.47	.013	-.020	216.45		-.00004	-1.44	.41	1.05
			(.554)	(.025)	(146.2)		(.0006)	(1.33)		

a. Reynolds and Timmons original estimates.

b. Pope and others estimates.

c. Remaining versions are new estimates

d. Expected signs on coefficients.

not occur in Tweeten and Martin's transfer equation. With little to recommend one equation over the other, the new estimates followed precedent and used equation 13 to predict transfers for use in the price equation.

Reynolds and Timmons also estimated several versions of their price equation, and used two different specifications of farmland value as the dependent variable, namely value of farmland and buildings (V1) and value of farmland without buildings (V2). Table 9 presents results using the former dependent variable, and table 10 contains results for the latter. Both sets of equations performed well in the original runs, with signs always expected and a high degree of explanation of variation in farmland values evident. Pope and others chose equation 17 to represent the price equation and reported four sign changes out of seven possible in the equation. The new estimate of this equation was a little more encouraging, with sign changes in the coefficient for interest (1/r) and the government spending variables only, and a high coefficient of determination, 0.96.

Of special interest in a comparison of all the estimates in both tables is the poor performance of the transfer variable, as predicted by equation 13. This variable also did not perform well in Tweeten and Martin's land price equation. This raises questions about the appropriateness of recursive transfer numbers as an indicator of quantity. It will be seen below, in considering the Klinefelter model, that when actual rather than estimated transfers appear, relations are still not always as expected.

The relationship between land values and the rate of interest, and land values and government payments are worthy of comments. In our new estimates, the rate of interest consistently produces the "wrong" sign, whether the variable appears in its original or inverted form. 15/ This is typical of results

15/ Reynolds and Timmons use 1/r to try to improve the fit following unsuccessful experiments with doubelog forms of the equations.

TABLE 9 - REYNOLDS AND TIMMONS EQUATIONS 14, 15 and 17: ESTIMATES OF VALUE OF FARMLAND AND BUILDING (VI)

Equation	Period	Constant	− T	+ GP	+ CP	+ A	− r	+ NFI	+ 1/r	+ GPL	CP	R^2	DW
14	1933-65[a]	107.98	-.23	12.08	.62	1.07	-5.73	2.91				.94	1.18
			(.14)	(2.55)	(.44)	(.69)	(1.33)	(.78)					
14	1944-78	-147.59	.068	-.0002	.001	.732	9.41	.0004				.96	1.22
			(.08)	(.003)	(.0004)	(.089)	(3.02)	(.001)					
14	1944-60	-142.76	.182	-.002	-.0003	.790	1.477	.0005				.90	2.22
			(.140)	(.006)	(.007)	(.304)	(3.03)	(.001)					
14	1961-78	43.77	-.930	-.0007	-.0001	.340	22.07	.0009				.88	1.34
			(1.10)	(.008)	(.001)	(.274)	(11.0)	(.003)					
15	1933-65	45.92	-.20	10.32	.42	1.29		2.69	1.45			.96	1.48
			(.04)	(2.38)	(.41)	(.64)		(.71)	(.27)				
15	1944-78	-75.12	.057	.0001	.0001	.736		.0009	-160.57			.96	1.19
			(0.84)	(.003)	(.0004)	(.093)		(.001)	(60.81)				
15	1944-60	131.5	.182	-.003	-.0004	.787		.0006	-19.24			.89	2.15
			(.157)	(.007)	(.0007)	(.036)		(.001)	(78.88)				
15	1961-78	224.4	-1.29	-.004	.0001	.365		.001	-238.71			.84	1.33
			(1.26)	(.009)	(.0001)	(.327)		(.004)	(210.74)				
17	1933-65[a]	55.42	-.15		.34	1.25		1.88	1.09	16.96	1.71	.97	1.76
			(.04)		(.36)	(.56)		(.68)	(.27)	(3.00)	(3.49)		
17	1946-72[b]	36.53	.003		.117	-.001		-2.89	22.92	23.63	-96.32		
			(.717)		(.443)	(.02)		(1.02)	(1.27)	(6.40)	(1.79)		
17	1944-78	-109.73	-.072		.0008	.783		.003	-178.81	-.0002	.083	.96	1.28
			(.09)		(.0004)	(.085)		(.001)	(58.64)	(.004)	(:039)		
17	1944-60	-150.43	.144		-.0003	.836		.001	-41.61	-.003	.015	.91	2.30
			(1.76)		(.0008)	(3.47)		(.002)	(71.81)	(.008)	(.043)		
17	1961-78	120.79	-.087		.0003	.494		.001	-270.4)	-.002	.045	.87	1.34
			(1.25)		(.001)	(5.89)		(.004)	(210.4)	(.014)	(.200)		

a. Reynolds and Timmons original estimates.

b. Pope and others stimates.

TABLE 10 – REYNOLDS AND TIMMONS EQUATIONS 20, 21 and 23: ESTIMATES OF VALUE

FARMLAND WITHOUT BUILDINGS (V2)

Equation	Period	Constant	− T	+ GP	+ CG	+ A	− r	+ NFI	+ 1/r	+ GPL	CP	R^2	DW
20	1933-65[a]	78.41	-.19	12.06	.43	1.25	-5.33	2.83				.94	1.08
			(.04)	(2.43)	(.42)	(.66)	(1.26	(.74)					
20	1944-78	-163.19	.106	.0009	.0008	.785	9.08	.0003				.97	1.07
			(.072)	(.003)	(.0004)	(.080)	(2.72)	(.001)					
20	1944-60	-142.36	.181	-.002	-.0003	.789	1.48	.0005				.90	2.22
			(.140)	(.006)	(.0007)	(.303)	(3.03)	(.001)					
20	1961-78	49.31	-.99	-.001	-.0003	.422	19.18	.00002				.89	1.21
			(.98)	(.007)	(.0009)	(.245)	(9.84)	(.003)					
21	1933-65[a]	19.51	-.17	10.37	.22	1.49		2.62	1.38			.95	1.47
			(.04)	(2.22)	(.39)	(.60)		(.67)	(.26)				
21	1944-78	-95.02	.096	.001	.0007	0.79		.0008	-151.42			.97	1.04
			(0.77)	(.003)	(.0004)	(.085)		(.001)	(55.60)				
21	1944-60	131.2	.181	-.003	-.0003	.786		.0006	-19.29			.89	2.16
			(.156)	(.007)	(.0007)	(.358)		(.001)	(78.74)				
21	1961-78	203.54	-1.32	-.004	-.0001	.449		-.00003	-197.25			.86	1.23
			(1.11)	(.008)	(.001)	(.289)		(.003)	(186.74)				
23	1933-65[a]		-.11		.13	1.45		1.73	.98	17.65	.92	.97	1.93
			(.03)		(.31)	(.48)		(.58)	(.23)	(2.59)	(3.01)		
23	1944-78	-124.89	-.0003		.0005	.833		.002	-167.1	.001	.068	.97	1.14
			(.084)		(.0004)	(0.77)		(.001)	(52.67)	(.004)	(.035)		
23	1944-60	-150.1	.143		-.0003	.834		.001	-41.59	-.003	.015		
			(1.75)		(.0008)	(.346)		(.002)	(71.70)	(.008)	(.043)		
23	1961-78	53.04	-.841		.0001	.690		-.0001	-205.2	-.005	.091	.90	1.20
			(1.04)		(.0009)	(.492)		(.003)	(175.6)	(.012)	(.167)		

a. Reynolds and Timmons original estimates.

with other models. Coefficient signs on variables representing government expenditures also showed some tendency to change sign. In certain of the equations, this variable was broken out into payments for land diversion (GPL) and conservation payments (CP). These coefficients showed different signs in equation 17, and in equation 23 for the 1961-78 period.

In sum, our estimates of the original model have not corroborated all of the original findings, although the new estimates are not so pessimistic as the runs by Pope and others, and the equations do explain a large amount of the variation in the dependent variables. Unlike the findings for the Tweeten and Martin model, estimates for the most recent period (1961-78) are particularly liable to provide unexpected results. The insertion of capital gains into the price equation seems to have been useful: this finding will be examined further below.

The two-equation model of Reynolds and Timmons appears to have a slight edge over the entire period than Tweeten and Martin's 5-equation model, though it appeared somewhat less adaptable to very recent developments. We now turn to a more orthodox supply-demand model, to see if this can improve on the recursive approaches above.

Herdt and Cochrane [3]

Herdt and Cochrane, like Reynolds and Timmons, propose a two-equation model of the land market, but rather than use a recursive system to explain farmland price variations, they use the orthodox supply-demand framework. That is, they assume that supply and demand determine prices jointly and that the market is cleared each year.

The equations proposed by Herdt and Cochrane and the definitions of variables used appear in table 11. They emphasize the supply equation, claiming that discussions of farmland prices have tended to concentrate too much on demand. On the demand side, technological advance is emphasized, being defined as "the capability of the firm to produce a greater amount of output for every

TABLE 11 - THE HERDT AND COCHRANE MODEL - EQUATIONS AND VARIABLES

N^a P; R, U, Lf	(Supply relation)
N^d, P; R, T, Pr/Pp, Lu G	(Demand relation)
N^a=N^d	(Market-clearing relation)

The variables are identified as follows (the y's and z's are included here for later reference).

Jointly determined variables:

N^a=y_1 is the number of farms (per 1000 farms) supplied;
N^d=y_3 is the number of farms (per 1000 farms) demanded;
P=y_2 is the price of farm land (average value per acre of land and buildings in current dollars);

Predetermined variables:

R=z_1 is the interest rate (yield on high-grade bonds reported in Standard & Poor);
U=z_2 is unemployment as a percentage of civilian labor force;
Lf=z_3 is land in farms, million acres;
T=z_4 is the USDA index of productivity;
Pr/Pp=z_5 is the ratio of the index of prices received by farmers to the index of prices paid by farmers;
Lu=z_6 is urban land (urban, industrial, nonfarm residential, roads, railroads, unused wastelands, etc.[8]);
G=z_7 is the general price level (wholesale price index).

unit of input it commits to the production process." 16/ This is represented in their model by the USDA index of productivity. Gains from technological advance, they argue, increase net profit by allowing increases in output while the presence of government price supports maintain or increase profits.

The jointly-determined variables are numbers of farms and the price of farmland. The former is represented by transfers per 1000 farms—a variable we regard as being under a cloud at this stage because of its performance in the recursive models. The price of farmland is represented by the average value per acre of land and buildings. In the model, weighted averages are used for the general price level (G), ratio of prices received to prices paid (Pr/Pp), and technological advance (T). A three-year weighted-average of the form outlined above for the Reynolds and Timmons model was chosen. Other variables used were in current year values. The equations were estimated by two-stage least squares, for the period 1913-62. Dependent variables were transfers for the supply equation and farmland values for the demand equation. In the final analysis, then, there is some similarity to the recursive models.

The results of application of the supply equation are shown in table 12. Equation 1:1 is the original formulation of the equation as shown in table 11. Herdt and Cochrane's original estimates were disappointing. The coefficient of the price variable did not have the correct sign, a serious defect according to Herdt and Cochrane. When the equation was rerun for the 1937-78 period, the rate of interest (R) and land-in-farms (LF) variables changed signs compared to the 1913-62 run, leaving only one out of four variables with the expected sign. Only for the 1950-62 period do results conform to Herdt and Cochrane's expectations.

Herdt and Cochrane's response was to suggest that because supply is measured in terms of number of farms sold per 1000, the number of farm (NF) might

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16/ Herdt and Cochrane [3], p. 252.

reflect shifts of supply better than land in farms. With this substitution, new estimates were made, as shown in table 12. The coefficient of the price variable has the correct sign, and retained it over all other periods for which new estimates were made except the most recent, 1963-78. This improvement of the supply equation came at a cost, because the rate of interest (R) coefficent changed signs in Herdt and Cochrane's original estimates. A negative sign on this coefficient was also evident in Pope and others estimates of the equation for 1913-72, but all variables in our 1937-78 estimates have the signs Herdt and Cochrane expected. While this suggests that the problem with the R variable may be traced to the period before 1937, a look at the sub-period runs shows the rate of interest to be the variable most liable to sign change. Thus, as with the other models examined so far, the rate of interest seems not to be a useful variable in a farmland model. The success of the supply equation over the 1937-78 period is offset to some degree by the evidence from the most recent sub-period examined, 1963-78, in which not one of the coefficients has the expected sign.

Estimates of the demand equation are shown in table 13. Equation 1:2 is the formulation of the demand equation set out in table 11. In the Herdt and Cochrane estimates over the period 1913-62, three out of six coefficients had unexpected signs. Herdt and Cochrane were especially concerned about the technological advance (index of productivity) variable (T), and blamed the wrong sign on its coefficient on the high correlation between it and the urban land (Lu) variable. While the correlation persists in the new estimates, the technological advance coefficient has the expected sign, for the long period and all sub-periods. The relation between urban land and value of land is much weaker over this period than for the 1913-62 period.

TABLE 12 - HERDT AND COCHRANE'S EQUATIONS 1:1 AND 2:1:
THE SUPPLY EQUATIONS: NUMBER OF FARMS DEPENDENT

EQUATION 1:1

Period	+ P	+ R	- U	+ LF
1913-62[a]	-.176	.264	-1.197	.068
	(.067)	(2.661)	(.242)	(.032)
1937-78	-.014	-2.24	-1.571	-.114
	(.029)	(1.289)	(.345)	(.034)
1937-52	-6.61	-12.341	-.199	.161
	(3.78)	(7.02)	(.724)	(1.45)
1950-65	-.108	-.352	-.508	.0001
	(.067)	(2.002)	(.642)	(.026)
1963-78	-.041	.756	-.460	-.121
	(.022)	(1.397)	(.962)	(.115)

EQUATION 2:1

Period	+ P	+ R	- U	+ NF
1913-62[a]	.064	-5.672	-.789	.004
	(.119)	(1.224)	(.188)	(.003)
1913-72[b]	1.29	-19.42	-.357	.036
	(6.12)	(7.16)	(2.132)	(.078)
1937-78	.0003	2.89	-1.747	.008
	(.228)	(1.052)	(2.54)	(.0013)
1937-52	.322	-17.071	-1.138	.026
	(.321)	(7.87)	(.544)	(.013)
1946-72[b]	.244	-1.33	-.597	.00001
	(1.147)	(.336)	(.542)	(3.084)
1950-65	.048	2.489	-.360	.008
	(.087)	(2.105)	(.531)	(.003)
1963-78	-.049	-1.136	.32	-.022
	(.023)	(2.286)	(1.061)	(.015)

a. Herdt and Cochrane's original estimates.

b. Pope and others estimates.

Remaining versions are new estimates.

TABLE 13 – HERDT AND COCHRANE'S EQUATIONS 1:2 and 2:2: THE DEMAND EQUATIONS: PRICE OF FARM LAND DEPENDENT

EQUATION 1:2

	−	−	+	+	+	+
Period	N^d	R	T	Pr/Pp	Lu	G
1913-62[a]	-3.512	7.119	-1.161	2.371	4.347	-3.187
	(.770)	(1.796)	(.549)	(.462)	(.839)	(.195)
1937-78	.797	2.658	.670	-2.288	-.00001	1.915
	(.877)	(3.751)	(.96)	(.607)	(.00001)	(.234)
1937-52	-.969	-10.503	.072	.574	.0001	.381
	(.159)	(4.722)	(.355)	(.132)	(.00002)	(.070)
1950-65	1.202	-15.225	2.424	.650	.0001	-.159
	(2.251)	(9.818)	(.247)	(.428)	.0001)	(1.082)
1963-78	-3.719)	-1.936	2.448	-2.732	.003	1.927
	(.713)	(3.733)	(2.605)	(.878)	(.008)	(.283)

EQUATION 2:2

	−	−	+	+	+
Period	N^d	R	T	Pr/Pp	G
1912-62[a]	-1.043	8.135	1.699	.757	.379
	(.697)	(2.191)	(.321)	(.372)	(.158)
1913-72[b]	-1.117	18.94	2.35	1.00	-.335
	(2.27)	(16.80)	(7.32)	(2.80)	(.205)
1937-78	1.865	5.707	-1.080	-2.271	2.123
	(.838)	(4.062)	(.558)	(.713)	(.247)
1937-52	-.803	-3.856	.492	.385	.464
	(.171)	(4.734)	(.372)	(.132)	(.073)
1946-72[b]	.729	16.38	2.22	.400	.669
	(.409)	(2.62)	(3.25)	(.625)	(.547)
1950-65	-1.301	-4.717	2.441	.382	.856
	(.691)	(3.952)	(.247)	(.363)	(.648)
1963-78	-3.681	-2.783	1.83	-2.864	1.962
	(.672)	(2.689)	(1.81)	(.755)	(.253)

[a] Herdt and Cochrane's original estimates.

[b] Pope and others estimates. Remaining versions are new estimates.

The new estimates also yielded the expected signs on coefficients of wholesale prices (G), but signs on land transfers (Nd), rate of interest (R) and parity ratio (Pr/Pp) coefficents reversed. Thus, although salvaging the technology relationship, the new estimates appear to perform no better than the original.

Herdt and Cochrane sought to improve on equation 2:1 by dropping the urban land variable. This was due to the correlation between it and index of productivity; intercorrelation may change the sign of a regression coefficient. The exclusion of Lu had the desired effect on the sign of the productivity index for the 1913-62 period (equation 2:2, table 13). Furthermore, only the troublesome interest rate variable now had a coefficient with the wrong sign. Pope and others found that the price variable (G) coefficient changed signs compared to Herdt and Cochrane's results; they commented, though, that in all the cases where sign changes occurred, none of the coefficients were statistically significant. According to the 1937-78 evidence, only one of the five variables (G) has the expected sign. Evidence from short-period estimates by both Pope and others and the present writers suggests that all relationships except the one between value of land and the general price level (G) were subject to short-period change. The equation is not a reliable one.

In their general commentary on the performance of their model, Herdt and Cochrane were most concerned about the interest rate variable. They suggested that other measures of interest rates might be tried, and, when such measures proved unsuccessful, that estimating procedures other than two-stage least squares be used to estimate equations. The spectre of misspecification did arise, but was exorcised by the "strong points" of the model. However, evidence from the other models considered here does not suggest that alternative measures of interest rates offer much hope. Furthermore, the strong points of their model (correct signs) were not stable when the time period for estimation changed. Pope and others tried an alternative estimating procedure, three stage least squares. They compared the two "improved" versions of the equations (2:1 and 2:2) estimated using 2SLS and 3SLS by a root-mean-square error test and found that 2SLS estimates outperformed the 3SLS estimates. This, together with the poor performance of the demand equation over the 1937-78 period brings back the spectre of misspecification. 17/

As a final step in their analysis, Herdt and Cochrane estimated the reduced form coefficients of their system. Their estimates and the results of the new estimates are given in Table 14. These coefficients can be used to estimate the effect of a one-unit change in each of the predetermined variables on the jointly-determined variables. Again, the frequency of sign changes of coefficients is notable when the time-period of the study is changed. Herdt and Cochrane also standarized the effect of each predetermined variable and concluded that, on the supply side, interest rate (with the perverse sign), unemployment, and number of farms were relatively important determinants. On the demand side, technological advance was "decisively the most important." This latter finding supported their earlier contentions about the importance of the effects of technological advance upon land prices.

17/ As Pope and others point out [8], p. 109.

> "It is apparent that for the within-sampling forecasting, both sets of 2SLS estimtes outperformed the 3SLS estimates. This is rather a surprising result, since econometricians generally prefer 3SLS over 2SLS due to a presumption of the latters' lack of asymptotic efficiency. However, the better forecasting performance of the 2SLS estimates may result from the fact that full information estimation methods, such as 2SLS, are more sensitive to specification errors than are k-class estimators such as 3SLS."

TABLE 14 - HERDT AND COCHRANE'S 'FINAL' REDUCED-FORM MODEL

Period	Jointly-Determined Variable	R	U	NF	T	Pr/Pp	G
1913-62[a]	N^s/N^d	-5.813	-.739	.004	-.102	-.045	-.023
1937-78	N^s/N^d	1.455	-.961	.014	.994	.309	-.137
1937-52	N^s/N^d	-10.76	-.825	.012	-.147	.487	-.093
1950-65	N^s/N^d	-.314	.142	.005	.160	.264	.524
1063-78	N^s/N^d	-.104	-.376	.027	3.031	.844	-.365
1913-62[a]	P	2.244	-.771	.004	1.592	.709	.355
1937-78	P	1.684	.522	.044	3.251	-1.606	1.753
1937-52	P	3.568	.664	-.018	.058	.081	.493
1950-65	P	-2.07	-1.304	-.005	2.249	-.126	-.137
1963-78	P	-4.05	-3.176	-.151	-11.706	-5.573	3.622

a. Herdt and Cochrane's estimates. Remaining estimates are new.

This experiment with a standard supply-demand model had some success from the supply side, but largely failed to specify the demand side. Sign instability of the reduced form equation does not add to its credibility. Evidence suggests that misspecification of the model is a problem, but in view of the Pope and others 3SLS findings, and the problems with significance of individual variables, one could just as easily point out other sources of lack of success of the model. When added to the evidence from the other models, there is cause for concern about the possibilities for econometric modelling of this market. One avenue not yet discussed is that of using a single-equation model. Such a model has been proposed by Klinefelter, and will now be examined.

Klinefelter [5]

Klinefelter used a single-equation model estimated by least-squares to estimate the effects of the variables shown in table 15 upon the value of Illinois farmland. His model was:

$$V = f(P, NR, E(Cg), A, C, T, GP)$$

Expected capital gains were estimated by the three-year moving average process described above. 18/ Klinefelter's study was confined to Illinois only, but the hypotheses behind the model and the expected sign pattern are of general application to the U.S. market. The Illinois results were presented in four versions of the equation. A fifth version was added by Pope and others, who applied the model to U.S. data. They modified Klinefelter's equation 1 by using average value of farm real estate per acre as the dependent variable. In this study, three of Klinefelter's equations from Pope and others are estimated for recent U.S. data.

In equation 1, Klinefelter included all the variables specified in the model above. His results are compared to the new, U.S. estimates in table 16 (a). The new estimates do not include variable C, which Klinefelter found to

18/ Above, p. 9.

TABLE 15 - DEFINITIONS OF VARIABLES
USED IN KLINEFELTER'S MODEL

ation	Description
	Average farm size (acres)
	Intercept
	Moving average corn yield for the previous three years, bushels per acre
	Capital gains in the previous year (dollars per acre)
	Moving average capital gain for the previous three years (dollars per acre)
	Expected capital gain (dollars per acre)
	Expected net returns to farmland (dollars per acre)
	Government program payments (dollars per acre)
	Net rent in the previous year (dollars per acre)
	Moving average net rent for the previous three years (dollars per acre)
	Implicit price deflator for Gross National Product (1957-1959 = 100)
	Voluntary transfers of farmland (number)
	Index of the value of Illinois farmland (1957-1959 = 100)

have a strong intercorrelation with variable A. While equation 1 provided a good explanation of changes in Illinois farmland value, coefficients of two variables, transfers and government payments, (T, GP), had signs inconsistent with theory. Further, the coefficients of these variables and expected capital gains [E(Cg)] were not significantly different from zero at the 20 percent level. This prompted Klinefelter to exclude some variables from the equation to form equations, 2, 3, and 4. In the U.S. runs for the same period, GP has the expected sign—a surprise in view of the perverse performance of this variable in the Reynolds and Timmons model. For these estimates, USDA capital gains figures were substituted for Klinefelter's capital gains variable, since the latter, by using changes in farmland value as a proxy for capital gains, seems to be uncomfortably close in definition to the dependent variable. Nonetheless, the equation estimated for the U.S. performs little better than the one for Illinois. Subsequent estimates were made for the 1937-78 and 1944-78 periods. A feature of these estimates is that the value of the coefficient on inflation (PI) drops dramatically compared to the 1951-70 runs, suggesting the surprising result that inflation has had less impact over the longer period. Signs on the coefficients of E(Cg) and GP are as expected throughout, but the remaining coefficients are all subject to sign changes. No one equation has all correct signs.

In part (b) of table 16, average value of farmland per acre is substituted for the index of farmland value as dependent variable. This is in order to facilitate comparison of Klinefelter's full model with Pope and others modified version, to be presented later. The drop in value of the coefficient on inflation occurs again, and only this variable and GP maintain their expected signs for all estimates. Combining evidence of both tables, Klinefelter's capital gains data perform much better than the USDA capital gains data. This

TABLE 16 - KLINEFELTER'S EQUATION 1: ESTIMATES OF VALUE OF FARMLAND

(a) DEPENDENT VARIABLE = INDEX OF FARMLAND VALUE

Period	+ PI	+ NR	+ E(Cg)	+ AS	− T	+ GP	R^2	DW	C
1951-70 (IL)[a]	1.305	1.317	.211	.698	.003	-1.261	.99	1.79	-4.335
	(.303)	(.557)	(1.803)	(.294)	(.003)	(1.287)			(.3811)
1951-70 (US)[b]	.992	.011	-.0003	.158	.659	4.605	.99	1.64	
	(.273)	(.004)	(.0003)	(.079)	(.409)	(1.486)			
1938-78	.006	-.0002	3.754	.292	.036	3.071	.97	1.57	
	(.002)	(.001)	(.275)	(.076)	(.312)	(4.001)			
1944-78 (1)[c]	.004	.001	3.289	.332	.242	4.104	.97	1.43	
	(.002)	(.002)	(.433)	(.086)	(.373)	(4.360)			
1944-78 (2)[d]	.0005	.049	.002	-.119	-1.012	20.424	.98	1.04	
	(.0013)	(.004)	(.0004)	(.093)	(.377)	3.635)			

(b) DEPENDENT VARIABLE = AVERAGE VALUE OF FARMLAND PER ACRE

Period	+ PI	+ NR	+ E(Cg)	+ AS	− T	+ GP	R^2	DW
1951-70 (US)	1.312	.025	-.0003	.342	.769	6.099	.99	2.33
	(.626)	(.009)	(.0006)	(.182)	(.936)	(3.402)		
1938-78	.009	-.0006	6.026	.479	.045	3.888	.98	1.77
	(.002)	(.002)	(.409)	(.113)	(.464)	(5.955)		
1944-78 (1)[c]	.007	.002	5.311	.540	.362	5.484	.98	1.63
	(.003)	(.002)	(.643)	(.127)	(.553)	(6.463)		
1944-78 (2)[d]	.0008	.077	.003	-.186	-1.668	32.108	.98	1.05
	(.002)	(.005)	(.006)	(.133)	(.539)	5.198)		

a. Klinefelter's original estimates. The independent variable C has been excluded in the new estimates in view of its poor performance in the original equation. The data used is for Illinois only.

b. This and subsequent estimates are for U.S. data.

c. This equation, like Klinefelter's Illinois estimates and these for 1938-78, defines capital gains as the change in per acre value of farmland and buildings over a year.

d. This equation, like the 1951-70 (US) equation, uses USDA estimates of capital gains.

is not, however, a criticism of the latter data, since Klinefelter's capital gains are computed from lagged values of the dependent variable.

As mentioned above, the disappointing performance of Klinefelter's equation 1 prompted a change in the specification of the equation. In equation 2, V, NR, ECg and GP were deflated by P to remove trends in monetary variables attributable to inflation, and thus PI was dropped as an independent variable. Table 17 contains estimates of this equation. All of the coefficient except government payments (GP/P) had the expected signs, although NR and T were found not to be significant at the 20 percent level. Klinefelter explained the negative sign on GP/P by high intercorrelation between it and AS. GP/P was then dropped from equation 2 to form equation 3, which is also presented in table 17. In equation 3, all variables had correct signs for the Illinois run, although NR is still not significant. A further estimate of equation 3 using logarithmic transformation of all variables failed to improve on the results shown.

Examination of U.S. estimates of equation 2 suggests that the poor performance of GP/P may have been an Illinois phenomenon. For the longer periods, all coefficients had expected signs, though the degree of explanation of variations in the dependent variable (R^2) falls compared to the 1951-70 equations. Once again, the USDA capital gains data do not perform as well as Klinefelter's estimates. Longer period estimates of equation 3 also contain expected signs on variables, but explain less variation in the dependent variable. The transfers (T) variable had unexpected signs in the 1951-70 estimates of equations 2 and 3, for U.S. data. T has already proved itself unstable in sign in equations explaining price of farmland. 19/

Pope and others chose to modify the Klinefelter model in their comparison of econometric models of the land market. They chose to use average value of farm

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19/ See Tables t, 9, 10 and 13.

TABLE 17 - KLINEFELTER'S EQUATIONS 2 and 3: MODIFICATIONS OF EQUATION 1

(a) **EQUATION 2**

Period	+ NR/P	+ CG/P	+ GP/P	+ AS	− T	R^2	DW
1951-70 (IL)[a]	.035	.552	-1.694	.563	-.002	.98	1.58
	(.373)	(.157)	(.866)	(.093)	(.002)		
1951-70 (US)[b]	.010	0[c]	5.444	.002	.003	.99	2.05
	(.003)		(1.015)	(.0003)	(.002)		
1938-78	.003	1.40	8.759	.003	-.017	.84	1.63
	(.0006)	(.269)	(2.755)	(.0006)	(.005)		
1944-78 (1)	.006	.784	5.752	.006	-.0098	.88	1.27
	(.0009)	(.283)	(2.567)	(.001)	(.005)		
1944-78 (2)[b]	.046	0	8.683	.003	-.006	.93	1.30
	(.003)		(2.027)	(.0005)	(.003)		

(b) **EQUATION 3**

Period	+ NR/P	+ CG/P	+ AS	− T	R^2	DW
1951-70 (IL)[a]	.238	.711	.406	-.004	.97	1.56
	(.377)	(.147)	(.052)	(.002)		
1951-70 (US)[b]	.008	0	.004	.009		
	(.004)		(.0002)	(.003)		
1938-78	.003	1.21	.003	-.016	.79	1.67
	(.0007)	(.293)	(.0006)	(.005)		
1944-78 (1)	.006	.562	.007	-.008	.86	1.26
	(.0009)	(.282)	(.001)	(.005)		
1944-78 (2)[b]	.041	0	.004	-.004	.88	1.66
	(.004)		(.0005)	(.004)		

a. Klinefelter's original estimates for Illinois. Remaining estimates are for U.S. data.

b. In these equations, CG is measured using USDA capital gains data.

c. A figure of zero is entered where a coefficient has a value $>|.00001|$.

real estate per acre as dependent variable, and replace net rent per acre, which Klinefelter used to represent the share of net farm income allocated to land, by net farm income. Pope's equation is shown in table 18. Pope and others estimated the equation for two periods, 1913-72 and 1946-72. The equation fits the data well in both cases; it also provided a good fit over periods chosen for the new estimates. Signs were not all as expected, however. Like Klinefelter's equation 1, only the coefficient of the inflation variable (P) consistently provides the correct sign. Net farm income seems to perform worse than net rent as a proxy for earnings of land. In the new estimates, capital gains were presented both for USDA and for Klinefelter definitions. The former are subject to sign changes, and are only weakly significant. As Pope and others point out, this simple model produces implausible signs, but fits the data well.

The apparent strong evidence of positive relationships between net rents and farmland values, and capital gains and farmland values in Klinefelter's models attracted some interest, especially from Melichar [6] who was investigating these very relationships using a different method. 20/ Reynolds and Timmons' study also identified these relationships. The relationships came out stronger as Klinefelter trimmed down his equation to equation 3. It has been noted that the use of alternative data on capital gains and earnings of land influences the relationships adversely.

In sum, study of the Klinefelter model has shown that a simple, single-equation model can produce results as "good" as more complex models. In view of this, and given the emphasis on net returns and capital gains as determinants of farmland value, it is tempting to trim Klinefelter's model even further, and include only these two variables as independent variables. This is done in the ensuing section.

20/ The method is known as "factor shares an analysis," and invovles attributing a return to production assets (including farmland). For a full explanation see Doll and Widdows [1].

TABLE 18 - MODIFIED KLINEFELTER 1 EQUATION

Period	+ P	+ NFI	+ Cg	+ A	− T	R^2	DW
1913-72[a]	2.684	-.005	2.410	-.054	-.250	.95	2.58
	(7.694)	(5.75)	(4.131)	(.683)	(1.283)		
1938-78[c]	-1.363	-.0012	6.078	.541	.135	.98	1.75
	(3.781)	(.0011)	(.398)	(.061)	(.439)		
1946-72[a]	1.136	.004	.220	.568	.953	.99	0.71
	(3.781)	(3.128)	(.575)	(7.056)	(5.705)		
1951-70[b]	1.472	.021	-.001	.501	1.636	.99	2.37
	(.667)	(.01)	(.001)	(.171)	(.863)		
1954-778[c]	-.009	-.001	6.159	.578	1.547	.97	1.70
	(.003)	(.003)	(.997)	(.139)	(1.561)		
1954-78[b](2)	.004	.008	.005	.379	-7.559	.96	1.18
	(.003)	(.002)	(.009)	(.191)	(1.758)		

a. Pope and others estimates, U.S.-wide.

b. New estimates, U.S.-wide, using USDA concept of capital gains.

c. New estimates using Klinefelter's concept of capital gains, U.S.-wide.

Capital Gains, Net Returns and Farmland Values: A Simple Model

In a recent article in the American Journal of Agricultural Economics, Melichar has focused attention on the influences of capital gains and net returns to farm production assets on farmland values. 21/ Melichar used the USDA series on real capital gains and net returns to production assets to show that recent price increases in farmland are justified by earnings attributable to land. In view of this and the evidence of the Klinefelter model, it is of interest to investigate the link between these variables. One simple model is of the form

$$V = f(E(Cg), NR)$$

where V = average value of farmland and buildings per acre, deflated by the index of prices farmers paid for living and production items.

E(Cg) = expected capital gains, using the 3-years weighted-average procedure of Reynolds and Timmons,

NR = net returns to farm production assets, calculated directly using USDA methods, deflated by the price index and lagged one year.

Because net returns were available only from 1950 onward, the period covered was 1951-78. Results are shown in table 19 and labelled as the "OLS" model. It was expected that both of the independent variables would be positively related to farmland values; both higher earnings and larger capital gains should be translated into higher farmland prices.

The simple model presented here confirms the positive relationships postulated above. The model, first estimated using OLS yielded coefficients with expected signs, and an R^2 of 0.57. Both regression coefficients were significant at the five percent level. The Durbin-Watson statistic was, however, unacceptable. For completeness, the simple regression between each dependent variable and farmland value are also given in table 19.

21/ Melichar [6].

TABLE 19 - RELATIONSHIPS BETWEEN LAND VALUES, CAPITAL GAINS, AND NET RETURNS TO FARM PRODUCTION ASSETS

Model [a]	Constant	+ NR	+b CG	+ V_{t-1}	R^2	DW	MSE
OLS	9.49	.004 (.001)	.0003 (.0001)		.57	.55	
ALS (LAG 1)	11.67	.002 (.001)	.0002 (.0001)		.29		4.30
ALS (LAG 3)	10.12	.004 (.001)	.0003 (.0001)		.46		3.87
DL	0.29	.0006 (.0005)	.0001 (.0001)	.970 (.067)	.95	2.54	
OLS	9.38	.006 (.002)			.36	.63	
ALS (LAG 1)	13.07	.002 (.001)			.08		5.51
DL	0.08	.0006 (.0005)		.992 (.06)	.95	2.42	
OLS	12.86		.0004 (.0001)		.41	.43	
ALS (LAG s)	14.13		.0002 (.0001)		.13		4.86
DL	0.26		.0001 (.0001)	1.014 (.056)	.95	2.60	

a. Period covered is 1951-78. Dependent variable is the real value of farm land and buildings per acre.

b. Capital gains defined differently for OLS, ALS, and DL models, as explained in the text.

Two further experiments were tried. First, autoregressive least square models were used to estimate the equation. These are labelled as "ALS" models in table 19. Although the signs remained as expected, neither a one-period nor a three-period autoregressive scheme improved on the fit of the OLS estimates. In view of the general lack of success with logarithmic versions of equations noted by some of the authors of the models examined here, no experiment was tried with this.

Second, to embrace the possibility that the dependent variable is responding gradually to changes in the explanatory variables over a long period prior to any particular year, a distributed lag model was fitted to the data. The structure selected for the model was the Koyck distributed lag. The form of equation fitted to the data was the following,

$$V_t = a + \lambda V_{t-1} + b_1 \, NR_t + b_2 \, Cg_t + E_t$$

The results of estimating this equation appear in table 19 for the models labelled "DL." The estimations yield very high values of R^2, but relationships are dominated by the lagged dependent variable, V_{t-1}. In no case are the coefficients of the NR or Cg variables significant at even the 20 percent level.

In the literature on Koyck distributed lag models, the lag coefficient is said to measure the rate of decay of the distributed lags. That is, the lag coefficients on exogenous variables decline in the form of a geometric progression

$$b_i = \lambda^i bo$$

In the original model containing one exogenous variable,

$$y_t = ao + bo \, Xt + b_1 \, X_{t-1} + b_2 \, X_{t-2} + - - - + u_t$$

The value of λ of 0.97 for the equation above thus represents a slow rate of decay of the effect of previous years' exogenous variables on the value of land. This would explain the relatively weak effect of current values of returns to assets and capital gains on land values. Looking at this another way, the difference $(1 - \lambda)$ is referred to as the speed of adjustment of the model. In the equation tested here, a value of $(1 - \lambda)$ of 0.03 is indicated, a very slow speed of adjustment. In the above, it is assumed that $0 < \lambda < 1$; the equation

$$Vt = a + \lambda V_{t-1} + b\ Cg_t$$

produced a value of of 1.01, thus violating the assumptions of the model. Finally the mean lag in a distributed lag model can be estimated $\lambda/1-\lambda$. Given $\lambda = 0.97$, a mean lag of 32 years is indicated. This would seem to suggest that explanation of current year land values must be sought much further back in the past than the expectations formula based on a three-year average!

In sum, the relationships between net returns to production assets, capital gains and land values displayed the expected signs. The distributed lag model fitted data better than did OIS and ALS, but relationships were dominated by the lagged dependent variable. Results suggest a slow speed of adjustment of the dependent variable to changes in the exogenous variables.

Concluding Comments

To conclude this paper, the difficulties that have arisen in the modelling of the land market will be reviewed, since it cannot be claimed that any of the models examined has provided an accurate description of the land market. Each step of the way from theory to actual testing has involved problems; these will be grouped into three areas— theory, specification of variables and technique.

For the most part, the various authors agree on the theoretical analysis of the land market. That is, in the preamble to the models, the proposed casual relationships are described in a similar manner. General agreement exists in support of the hypotheses that increases in farmland value will accompany increased returns to land, anticipated capital gains, economies of scale in farming and general price inflation. All models postulate an inverse relationship between quantity of farmland for sale and farmland prices. When discussing theory, authors have seen alternative possibilities in theoretical relationships. In our discçussion of Tweeten and Martin's model, attention was drawn to their comments about the sign on capital gains, and ratio of average earnings of factory workers to those of farm workers. Another instance was Klinefelter's discussion of technology, where technological improvement could cause a decrease in farm income and farmland prices where demand for products is inelastic, but could increase farmland values when coupled with price supports. 22/ This latter discussion brings up a further related problem, that theoretical relationships between two variables often involve some secondary relationship that incorporates further varaiables. In the case of technology and price supports this was foreseen. In other cases, complications emerged in the course of testing the models, and were overcome by dropping variables which were intercorrelated. An example is the relationship between technology and the degree of urbanization which became evident in Herdt and Cochrane's model. 23/

Once theoretical relationships were postulated, the next step was to specify models and variables. When selecting variables, proxies are often utilized to capture a desired "economic" effect, even though data availability is less of a problem in agriculture than in some other areas of the economy. Our comparisons of models indicate that results are sensitive to changes in proxies used; different proxies were used in different models. We attempted to improve measurements of the effects of capital gains and land earnings by using the USDA Balance Sheet of Agriculture estimates in the reruns of the models;

22/ Klinefelter [5], p. 28. There is also a discussion of the point in Herdt and Cochrane [3], p. 248.

23/ Herdt and Cochrane [3], pp. 257-8. While it has not been the intent of this paper to add to the list of relationships, it might be observed at this stage that taxation is conspicuously absent from models.

inclusion of these new measures did not appear to improve results but did confirm the importance of these variables. In some other cases, the use of different proxies to represent a given effect did not improve results. The cases of government payments and interest rates are examples. Further problem proxy variables have been identified by Reinsel, who is particularly critical of the use of the U.S. Productivity Index by Herdt and Cochrane to represent technological change, and change in farm size to represent farm enlargement demand. 24/

As a means of demonstrating the variety of relationships postulated to explain changes in farmland value and their performance, table 20 lists the relationships involved in the various price equations, and the frequency of "correct" signs on the respective regression coefficents. Most variables were represented by more than one proxy, exceptions being transfers, lagged price, and parity. The data in table 20 suggest that capital gains and net earnings caused the least trouble--this was highlighted in table 19. Of the other relationships identified, only quantity of land, size of farms, and the general price level had the sign to be expected, a priori, in over 70 percent of the cases examined.

Perhaps the biggest disappointment among proxies was the transfers variable, which was used to represent quantify of farmland in all of the price equations. Transfers are used because only a small proportion of all farmland is placed on the market at any one time, and hence total quantity is not appropriate. Voluntary transfers of land over a period is the most obvious proxy for quantity, because it represents the land sold over a period. In the recursive models,

24/ Correspondence with Doll and Widdows, May 1980. Reinsel also pointed out that models fail to stress relationships between farm financing and farmland value, and taxation and farmland value.

TABLE 20 - VARIABLES USED TO EXPLAIN CHANGES IN FARM PRICES AND THE FREQUENCY OF CONFIRMATION OF EXPECTED SIGNS ON THE COEFFICIENTS FOR THESE VARIABLES*

Variable	Total Appearances	Times Sign Correct	Times Incorrect	Correct / Total
Quantity of Land	11	8	3	.73
Size of Farms	21	16	5	.76
Transfers	26	14	12	.54
Net Earnings	17	15	2	.88
Interest Rates	22	11	11	.50
Lagged Price	9	6	3	.67
Productivity	6	4	2	.67
Parity	6	4	2	.67
General Price Level	9	7	2	.78
Government Payments	13	9	4	.69
Capital Gains	12	11	1	.92

* Sources are Tables 6, 9, 13, and 16. Only long-period runs were considered. 26 equations were examined in all.

transfers were predicted by a separate equation; the success rate of predicted transfers was about the same as that of the original variable (0.58).

Farmland prices are also represented by a proxy, being represented by field estimates of farmland value rather than the actual sale price. Further, this value appears sometimes as an index, sometimes as a value per acre, and with or without the value of farm buildings. This means that special care must be taken to avoid problems of scale given the diverse units of measurements of independent variables. Such care is not always evident, nor may it always be possible, and may account for the observable success with variables expressed in dollar terms as opposed to those expressed in physical or ratio terms in Table 20.

Once proxies have been selected, the problem of current values, lagged values, or modified forms still remains. In general, models have included lagged variables by one period, although variables selected to be lagged have not been uniform. A more serious problem is variables whose influence on price is postulated to work through anticipations of future changes in the variable. This includes earnings and capital gains, and in some cases government payments and inflation. The formula for expectations in earnings and capital gains used in most models invariably utilized the standard three-year lag model. Such a three-year moving average would seem to be inappropriate in a market where both earnings and capital gains can be subject to cyclical fluctuations of more than three year duration. 25/ Some alternative formulation which say, emphasizes the last peak, or the difference between peaks and troughs might be preferred.

25/ Melichar [6], p. 1089, identifies cycles in U.S. agriculture since 1954. They do not conform to a three-year pattern.

Of course, the study of expectations is at present undergoing considerable activity—applications of emergent methods to this market would clearly be of interest given the importance being attached to capital gains and earnings in recent studies of farmland prices.

Studies have utilized time-series data for the most part; Reynolds and Timmons did investigate the use of cross-section data but found time series results to be superior. Periods used in some models covered years of diverse economic experience, with dummy variables used sparingly. Large structural changes in the market over time may thus have masked true effects. Sub-period estimates were derived for recent years in our reruns of the models, to see if structural instability of models was evident. There was consistent evidence of short-period changes in relationships. The Herdt and Cochrane and Reynolds and Timmons models performed better over the late 1940's and 1950's, while the Tweeten and Martin model performed better over the 1961-78 period. The vulnerability of signs of coefficients to sample period changes adds to our conclusion that the market has not yet been adequately modelled.

Finally, a few words about techniques. The examination of the different models enabled us to look at a range of techniques, from 5-equation recursive systems to single-equation models, and has enabled comparison of OLS, ALS, and RLS methods. We conclude that the single-equation OLS model is by no means overshadowed by more sophisticated methods, and benefits from its ease of application. Of course, the selection must ultimately rest upon the purpose to which the model is put: prediction versus structural estimation. Pope and others found the simple OLS models acceptable for predictive purposes.

One thing upon which the analysts have implicitly agreed is that there is a "U.S. land market" which is amenable to econometric analysis inspired by basic price theory. This is not necessarily a concensus view. In a paper parallel to this one, Doll and Widdows were lead to conclude the following on reviewing the general literature on farmland:

> "A theory of optimal behavior leading to supply and demand functions was not found to exist in the literature. The traditional supply and demand model clearly does not apply." 26/

This is not to deny the existence of a market for farmland, rather the attempt to formulate general relationships which apply across aggregate data for the U.S., as is done in the preamble to the models above, may be futile. Attention should perhaps be focused on local markets and/or specific relationships. Localized studies in particular can place much greater emphasis on local non-farm influences on the price of land.

For those who see a future in econometric modelling of the U.S. farmland market, there remains much work to be done on the fundamentals of the market--improvement of theory, refinement of techniques and improvement of data sources, to name but a few. Mere substitution of one estimating procedure for another or one proxy for another can at best only provide a marginal improvement on the results presented above.

26/ Doll and Widdows [1], p. 93.

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