A Time Series Analysis of Farmland Price Behaviour in Ireland, 1901-1986*

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Abstract: This paper examines the dynamic link between land prices and a proxy for agricultural returns, conacre rents, in Ireland. The data pertain to the Limerick region and span the period 1901 to 1986. Initial results suggest that rents do determine land prices but that the transmission process is considerably drawn out. Further analysis, however, reveals that the period of entry into the EEC caused considerable instability in the land market in Ireland. Once this instability is allowed for, we find the dynamic link between prices and rents to be quite similar in structure to what researchers have found to be the case elsewhere.

I INTRODUCTION AND BACKGROUND

P ast work in the agricultural economics literature has examined the link between agricultural return and land values. Phipps (1984), Alston (1986), Burt (1986), and Falk (1991) focus attention on the farmland market in the United States, while studies by Hyder and Maunder (1974), Traill (1979), and Harvey (1989) analyse and offer important insights regarding the land market in the United Kingdom. A strong conclusion to emerge from all of these studies is that agricultural return is critically influential in

determining farmland prices. Our interest in this paper lies in modelling the dynamic link between farm land price and a proxy for agricultural return (conacre rent) in Ireland.[1] Ireland is particularly fitting for a study of this nature because its economy, in contrast to that of the UK and that of the US, depends heavily on the agricultural sector.[2] Such dependence is germane in that it more easily allows isolation of the effect of farm return on land price than is the case in regions or areas where there exists a variety of competing uses for land.

The econometric technique we employ in the empirical work is time-series analysis. Specifically, we estimate a transfer function using farm-land prices as the dependent variable and using a measure of agricultural return as the input variable in the function. This technique is particularly well-suited to modelling the dynamic relationship between the dependent and input variables. The technique's main drawback, however, is that it precludes the estimation of a full-scale, econometric model of the land market. Other factors, such as farm commodity prices, technological advance, capital-labour ratios, and governmentally set farm programmes, that may also be important in determining farmland prices, are not accounted for explicitly in the modelling process.[3] Thus provision of a full-scale, econometric model of land price determination in Ireland is beyond the scope of our paper. Rather, we set the more modest objective of attempting to assess the degree of relationship and the dynamic structure of the relationship between farmland prices and rents in a homogeneous farming region (Limerick) within Ireland over the period 1901 to 1986.

The remainder of the paper is organised as follows. Section II presents a general model of the relationship between farmland price and agricultural return, and it discusses approaches and difficulties associated with estimating this model. Section III, using the Limerick data, tests for causality between farmland price and farm return and it estimates the transfer function model developed in Section II. Section IV discusses the time series results and extends the analysis further to account for Ireland's entry into the EEC and its subsequent adjustment to that event. Section V closes the paper with a summary and conclusions.

1. In this paper we will use the term "Ireland" to refer to the "Republic of Ireland".
2. In 1985 agriculture accounted for nearly 16 per cent of total civilian employment in Ireland compared with 2.6 per cent in the United Kingdom and 3.1 per cent in the United States. (*Source: OECD Economic Surveys — Ireland, 1987/1988.*)
3. The measure of agricultural returns should reflect, to some degree, the effect of these factors, however.

II A MODEL OF FARMLAND PRICE DETERMINATION

We can, of course, think of a farm in much the same way as we think of any profit maximising firm. Just as the value of the firm is the present value of the anticipated stream of profits, so too is the value of a farm equal to the present value of expected future net returns accruing to the land. The standard approach to modelling farmland price, then, has been to assume that the price of the land is equal to the present value of the future stream of net returns derived from use of the land.[4] Therefore:

$$V_0 = \int_0^\infty R_t \cdot e^{-rt} dt \qquad (1)$$

> where R_t is the net return to the land from farming in period t;
> and r is the discount rate.[5]

In this model, farmland value depends on future expectations of net return to the land. Growth in net return depends on factors such as farm commodity prices, farm input prices, governmentally set farm programmes, and technological advance. Aggregation of this relationship over all farms yields the relationship between income and land value at the sectoral level.

Phipps correctly points out, however, that, at the aggregate level, the relationship between the income generated by parcels of land in farming and the value of such parcels is not as airtight as Equation (1) might lead one to believe. The issue is essentially this: a tract of land can be used in farming but it might also be used in a variety of other activities (where commercial development is the standard example of an alternative use for farmland). If a tract of land is always employed in its most profitable use and the most profitable use of the land is not always in farming, then Equation (1) no longer holds and instead we have:

$$V_0 > \int_0^\infty R_t \cdot e^{-rt} dt \qquad (2)$$

In other words, the value of a tract of farmland depends not only on expectations of future returns from farming the tract, but also on expectations of the land's opportunity cost in alternative uses. If future income from farming

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4. See, for example, Alston, Burt, Phipps, Castle and Hoch (1982), or Melichar (1979).

5. We impose the simplifying restriction of a constant real discount rate. This assumption is used throughout much of the literature. Burt, p. 12, justifies the assumption on the grounds that the real discount rate is determined jointly by intertemporal consumer preferences and productivity changes, both of which are fairly stable over time. He also notes that farmland possesses long-term investment characteristics and entails sizeable transaction costs; therefore, farmers use a long-run equilibrium real rate of interest in the decision-making process.

the land exceeds its opportunity cost in all years, then Equation (1) holds
strictly. If, on the other hand, the opportunity cost of the land exceeds income
from the land when used for agricultural purposes in some future years, then
the inequality (2) holds and land value is dependent both on expected income
from farming and on the land's expected opportunity cost. Thus, in aggregate
time-series data two forces may conceivably be at work in determining
farmland value.

Establishing the econometric link between farmland value and agricul-
tural return is fairly straightforward if Equation (1) holds but becomes more
difficult if inequality (2) holds. To see why, begin by considering the simpler
case first. While we cannot observe land market participants' expectations of
future returns in farming, we can reasonably model the process by which
such expectations are formed. That is, expected future net return depends
fundamentally on past movements in net return. If net return follows a
particular time series process, then market participants with rational
expectations will be aware of this process and will use their knowledge to
forecast future movements in farm return.[6] Hence, land value should depend
systematically on the past behaviour of net return since expected future net
return is perceived as depending on past net return. Equation (1) can,
therefore, be rewritten as:

$$V_t = \sum_0^\infty B_i R_{t-i}$$

$$= (\beta_0 + \beta_1 L + \beta_2 L^2 + \ldots)R_t$$

$$= \beta(L)R_t$$

(3)

where L is the backward-shift operator.

Equation (3) is a standard transfer function. Box and Jenkins (1976) have
shown that a transfer function such as Equation (3) can be parsimoniously
paramaterised by the ratio of two polynomials in L with a finite number of
parameters:

$$V_t = \frac{\Theta(L)}{\delta(L)} R_t$$

(4)

According to Equation (4), land values will depend on current and past values
of the net return to land and on past values of land itself. On practical
grounds, Equation (4) is superior to Equation (3) because Equation (3)

6. Although this is not to deny that other conditions will also matter, such as expected
institutional changes or changes in governmental policies and programmes. These factors, unlike
past movements in an income series, tend to be non-quantifiable and often difficult to observe in
practice; therefore, incorporating them in an econometric model is problematic.

contains a large (perhaps infinite) number of parameters and, therefore, is not estimable.

If, on the other hand, inequality (2) holds, then land value could be modelled as jointly dependent on current and past movements in net income *and* in the opportunity cost of the land in uses outside of farming. The problem, of course, is that the opportunity cost of farmland is difficult to observe given the variety of alternative uses for farmland. Opportunity cost, as a consequence, ends up in the error term, causing a specification error and resulting in biased coefficient estimates.

It is possible, using time series techniques, to determine econometrically whether Equation (1) or inequality (2) holds. If Equation (1) holds, then net return will "cause" land values in the Granger sense of the term.[7] That is to say, net returns will serve as a leading indicator of land value. If, on the other hand, inequality (2) holds, then there will be evidence of "feedback" in the relationship between net returns and land value. Net returns, in other words, will serve as a leading indicator of land value, but the opposite will also be true.

To see this, suppose the expected future value of the opportunity cost of farmland increases. This occurrence will generate an immediate rise in V_0. The marginal value product of land will not change immediately, however. In the future, as land shifts out of agricultural use, agricultural commodity prices will likely rise due to a decline in supply and land's marginal physical product will increase through reverse operation of the law of diminishing marginal returns. Both factors will serve to raise the marginal value product of land and, therefore, its net return. So movements in V will be observed to lead movements in agricultural returns.

Econometrically, the direction of causality can be detected using standard, time-series techniques. If net returns cause land prices, but the reverse is not true, then Equation (4) can be estimated and the effect of the opportunity cost of farmland can be confidently ignored.

III EMPIRICAL ANALYSIS

3.1 *Data*

In order to estimate Equation (4), we use a data series on land prices from the Limerick region of Ireland and a proxy series for farm returns from the same region of the country. Limerick forms a homogeneous agricultural region, which is an important consideration necessary to avoid the feedback

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7.   Given the set Ω_t of all information in the universe at time t, the variable X is said to cause the variable Y if use of Ω_t results in a superior forecast of Y_{t+1} than does use of $\Omega_t - X_{t-j}$, $j \geq 0$. See, for example, Ashley, Granger, and Schmalensee (1980).

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problem noted above. The Limerick region contains some of the best farming land in the country, including prime quality pasture known as the "Golden Vale" which extends into County Tipperary from County Limerick. Primarily a dairying area, 31 per cent of County Limerick's employed workforce was engaged in agriculture in 1966, slightly above the national average.

The data were obtained from the auctioneering firm of Fitt and Company of Limerick, who kindly provided access to their detailed records of land sales and lettings dating back to 1901. The land price series we use in the work to follow is mean price paid for an acre of land in the Limerick area.[8] We call this series "the Auctioneer Series". The mean number of land purchase transactions in this series is 9 per annum.[9]

In Nunan (1987), the author compares the Auctioneer Series with other land price series, including some prepared by the Agricultural Institute and those derived from purchases of land by the Irish Land Commission over the period 1928 to 1985. He found a fairly high degree of correspondence among the various series compared. Figure 1 compares the Auctioneer Series with average prices paid by the Irish Land Commission (a) in County Limerick and, (b) in the country as a whole, for the period 1928-1985. It shows that the Auctioneer's land price series follows closely trends in the Land Commission series.[10] Land Commission prices are generally lower than those of the Auctioneer Series because the Land Commission normally did not purchase the best farms and, often, those acquired were in a run-down condition.

The Auctioneer Series possesses two distinct advantages over the other two series. First, because the Auctioneer Series is based on transactions made in the open market, it should be subject to the forces at work in the market to a greater degree than either of the two Land Commission series. Second, because the series is based on transactions conducted within a fairly homo-geneous region, we are able to hold constant, to some degree, factors that also can affect land values, such as regional differences in land quality, in non-agricultural uses of the land, and in institutional arrangements.

We use mean "conacre" rents for the Limerick region as our proxy for net

8.   These data were first published in Nunan (1987).
9.   The proportion of total land sold on the open market in Ireland is small. In a study of farmland transfer in the Republic of Ireland for the period 1950-1977, Kelly (1983) showed that there was low mobility of agricultural land between farm operators. Over this period, about 3 per cent of the land was transferred per annum and only about 13 per cent of that total changed ownership via the market.
10.   The Pearson product-moment correlation coefficient between the Auctioneer's series and the Land Commission series for Ireland is .912, while the coefficient is .943 between the Auctioneer's series and the Land Commission series for Limerick.
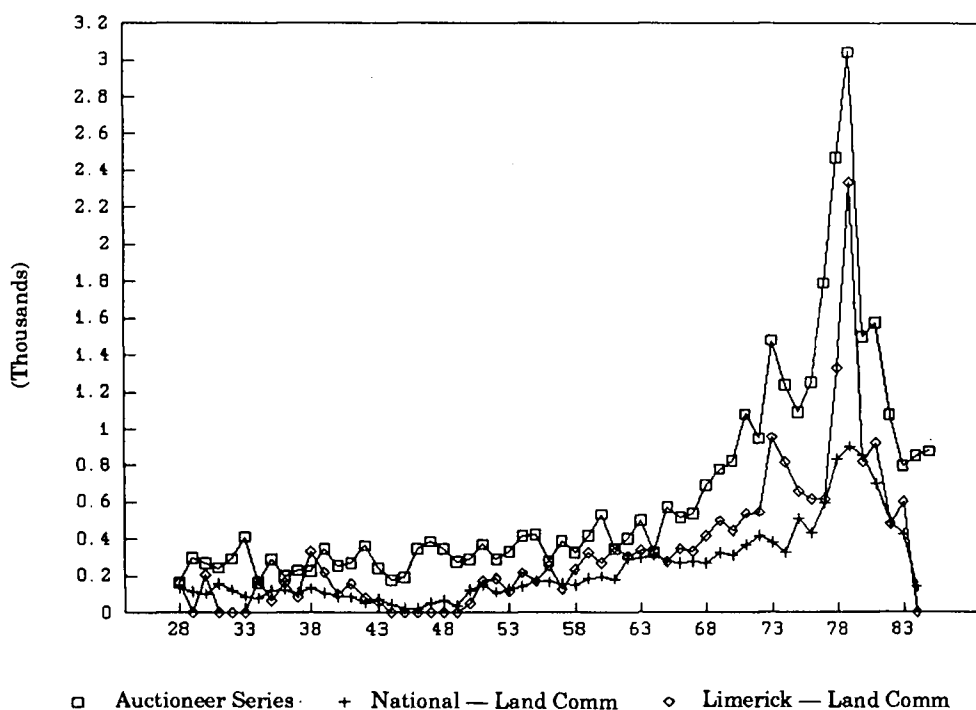
Figure 1: *Comparison of Auctioneer Series with Land Commission Series for Limerick and for all of Ireland**

*Note that observations for the Limerick Land Commission series were not available for 1929, 1931-1933, 1944-1949, and 1984-1985.

agricultural return (R_t).[11] These data were also drawn from the books of Fitt and Company. The mean number of lettings per annum in this series is 34.

Until the end of the last century, the landlord and tenant system was the dominant form of land tenure in Ireland. From about 1880 onwards, Land Acts were passed in the Parliament of the United Kingdom that facilitated the purchase of their holdings by the former tenants by means of long-term loans, introducing the current overwhelming predominance of owner-occupiership of agricultural land in Ireland. However, within the latter

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11. Empirical work in the farmland price literature uses one of two general types of proxy for agricultural return — cash rents or net farm income. Studies by Falk (1991), Alston (1986), Burt (1986), Vantreese, Skees, and Reed (1986), Robinson, Lins, and VenKataraman (1985), Brown and Brown (1984), Scott (1983), Castle and Hoch (1982), Hyder and Maunder (1974), and Klinefelter (1973) use cash rent data. Studies by Featherstone and Baker (1987), Vandeveer (1985), Phipps (1984), Shalit and Schmitz (1982), Barry (1980), Reinsel and Reinsel (1979), and Traill (1979) use measures of net farm income.

system, letting of land is still carried on, largely under the conacre system, which allows land to be let for eleven months or less without conferring on the person renting the land the rights normally associated with tenancy (Lund and Slater, 1979).[12]

In the empirical implementation of Equation (4), one would like ideally to use mean net farm returns for the Limerick region. Such data unfortunately are not available.[13] On the other hand, conacre rent data, like land prices, are readily observable. Moreover, conacre rents are normally bid on the open market for small lots of additional land and, therefore, approximate closely to the concept of expected marginal value product of land. Consequently, though they do not measure net farm income directly, they nevertheless act as a good barometer of anticipated changes in farming returns or profits.[14] Theoretically, conacre rents may be interpreted as the marginal surplus income accruing to land after the factors of production other than land have been rewarded. Under a predominantly owner-occupier system of land tenure, it is not necessary to distinguish within this surplus between Ricardian rent of land and economic profits.

Letting of land on conacre has been a common practice in Ireland for most of the years covered by this study. In later years, however, longer term leasing has become more common but has not eliminated the practice of conacre. In a survey of the pattern of land tenure, acquisition, and price in Ireland in 1977, Kelly (1979) found that 94 per cent of the rented land covered by the survey was let for 12 months or less (Kelly, Table 3). Over the period 1950-1975, the fraction of the total area of crops and pasture let on the conacre system varied from 5.3 per cent to 8.6 per cent (Kelly, Table 1).

3.2 *Estimation of the Transfer Function for the Period 1901-1986*

As noted in Section II, estimating the relationship between land prices and the return on land is a fairly straightforward task provided that farmland has no expected higher use in activities outside of farming. If this is not the case, then the relationship between net farm income and land price will exhibit

12. This system is very different from that of the landlord and tenant relationship in England and Wales, where rents have been controlled by statute and tenancies are mainly of complete farms for relatively long periods of time.

13. One could use aggregate income from self-employment and other trading income in agriculture from the national income accounts. These data possess the disadvantages that they only go back to 1938, they are aggregate and thus do not correspond directly to Limerick itself, and they include remuneration to labour and interest on capital employed as well as the return to land. See McGilvray (1968), p. 53.

14. In this regard, the following passage from Hyder and Maunder, p. 4, is instructive: "Farmers, however, have a choice between owning and renting, and it is likely that the market for land by purchase behaves in a very similar way to the market for land by renting. Rents are thus both a measure of the return to land and an indication of the price of land."

feedback and estimation of an equation like Equation (4) will be confounded by specification error.

As a first step toward estimating the relationship between conacre rents and farmland prices, we utilised the data described in the previous section for land purchased in the Limerick region between 1901 and 1986 to test for uni-directional causality from the input variable, rents, to the dependent variable, land prices. The standard method used in testing for causality between two time series is to compute the cross correlation function (CCF) of the two series and then to look for statistically significant cross correlations (see, for example, Vandaele, 1983). Prior to this step, however, one must ensure that individual behaviour on the part of either series (such as non-stationarity or autocorrelation) does not cause spurious correlation between the two series. In other words, testing for causality between the series can be complicated by the individual behaviour of the two series over time. If two time series, say X and Y, are not white noise processes, that is, X and Y are non-stationary (exhibit trend behaviour) or are autocorrelated, then a number of the cross correlations will turn up statistically significant. In the presence of non-stationarity or autocorrelation, however, one could not say with any degree of certainty that the significance was due to a causal relationship between the two variables; the relationship might just as likely be spurious as causal.

Because many time series are non-stationary and autocorrelated (and this is certainly likely to be the case for farmland price and rent data), one must first examine the relevant series for non-stationarity and autocorrelation before carrying out the cross correlation analysis outlined above. If non-stationarity is found to be a problem, then this is dealt with by a suitable transformation of the data. First differencing a time series is usually enough to render it stationary. Autocorrelation in a series is detected by examination of the autocorrelation function (ACF) of the differenced series. Statistically significant elements of the autocorrelation function are indicative of autocor-relation in the time series, and the autocorrelation function can be used to ascertain whether the series is governed by an autoregressive process, a moving average process, or some mixture of the two.

If a series does exhibit autocorrelation, a uni-variate filter can be fitted which reduces the series to a white noise process. Thus:

$$\begin{cases} \alpha(L)X_t = \varepsilon_{1t} \\ \phi(L)Y_t = \varepsilon_{2t} \end{cases} \qquad (5)$$

The residuals of the filtered series, ε_{1t} and ε_{2t}, are white noise. In other words, the portion of either series that could be explained simply in terms of

its own past behaviour is eliminated. Tendencies for changes in X to cause changes in Y (or vice versa), are not eliminated by this pre-whitening process, however. Hence, if X and Y are causally related, then the cross correlation function of the two whitened series will reveal this to be the case.[15]

Preliminary analysis of the price and the rent data revealed both series to be non-stationary. In order to reduce each to stationarity, we deflated by the consumer price index and then took first differences. Table 1 presents the autocorrelation functions of deflated price and rent, differenced price and rent, and whitened price and rent. Figures 2a and 2b present the autocorrelation functions of the price series and the differenced price series respectively. Figures 3a and 3b depict the autocorrelation functions of the conacre rent and differenced conacre rent series.

Figures 2a and 3a show that the price and rent series are non-stationary in their levels, since autocorrelations in both are initially high and then die off in a slow, exponential fashion. Figures 2b and 3b show that differencing reduces each series to stationarity, in that both of the autocorrelation functions of the differenced series die off rapidly.

While differencing induces stationarity in the series, it does not necessarily remove other systematic behaviour that may be explained by past movements of the series. We therefore investigated the possibility that the differenced price and rent series had not been reduced to white noise. The Ljung-Box statistic, at 10.05, for differenced prices given in Table 1 is not quite significant at the .10 level. Examination of the autocorrelation function in Column 3 of the table, however, reveals statistically significant values at the sixth and seventh lags, suggesting a high order, moving average process. On this basis, we experimented with several uni-variate models for price and found that an integrated moving average model (0,1,7) gave the best fit for the price series.[16] The resulting uni-variate model for Limerick land price is:[17]

$$(1 - L)P_t = (1 + .282L^6 - .315L^7)\hat{\varepsilon}_{1t} \qquad (6)$$

$$(.11) \qquad (.14)$$

$$\text{S.E.} = 235.02.$$

15. See Haugh (1976) on this point.
16. Insignificant coefficients have been constrained to zero in the final estimation.
17. Standard errors are in parenthesis.

Table 1: *Auto- and Cross-Correlation Functions: 1901-1986*

Autocorrelation Functions

Lag	Price	Differenced Price	Whitened Differenced Price	Rent	Differenced Rent	Whitened Differenced Rent
1	.87	−.12	−.02	.84	.07	.04
2	.77	−.01	−.01	.67	.00	−.03
3	.68	−.06	−.09	.50	−.17	.07
4	.60	−.14	−.21	.41	.16	.13
5	.55	−.03	−.06	.26	−.02	−.11
6	.51	.27	.02	.12	.05	−.03
7	.41	−.21	−.04	−.04	−.11	−.06
8	.36	.10	.14	-.13	−.21	.00
9	.28	−.12	−.05	−.17	−.17	−.02
10	.24	−.01	−.02	−.16	.07	.05
11	.19	−.02	−.04	−.18	.08	.01
12	.15	−.02	−.01	−.23	−.09	−.08

Ljung-Box Statistics: Price − Q(6) = 249.08
Differenced Price − Q(6) = 10.05.
Whitened Differenced Price − Q(6) = 5.16.
Rent − Q(6) = 149.03
Differenced Rent − Q(6) = 5.80.
Whitened Differenced Rent − Q(6) = 3.34.

Cross-Correlation Function: Whitened Land Price and Whitened Rent

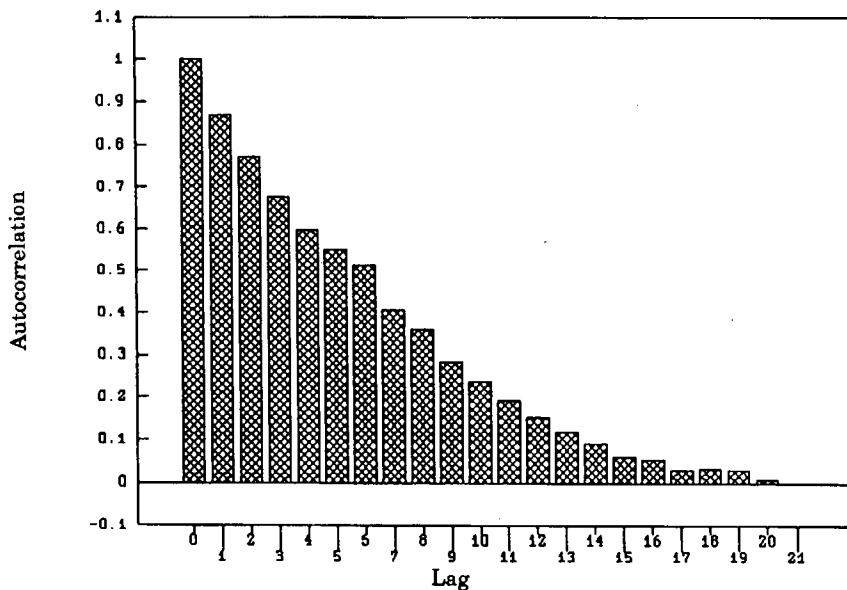| Lags	CCF	Leads	CCF
0	.42		
1	−.16	1	.10
2	.11	2	.01
3	.08	3	−.06
4	−.13	4	.08
5	.00	5	−.01
6	.07	6	.01
7	−.22	7	−.06
8	−.12	8	.04
9	−.20	9	−.03
10	.05	10	.05
11	−.03	11	.05
12	−.01	12	−.11

Leads − Q(6) = 1.82.

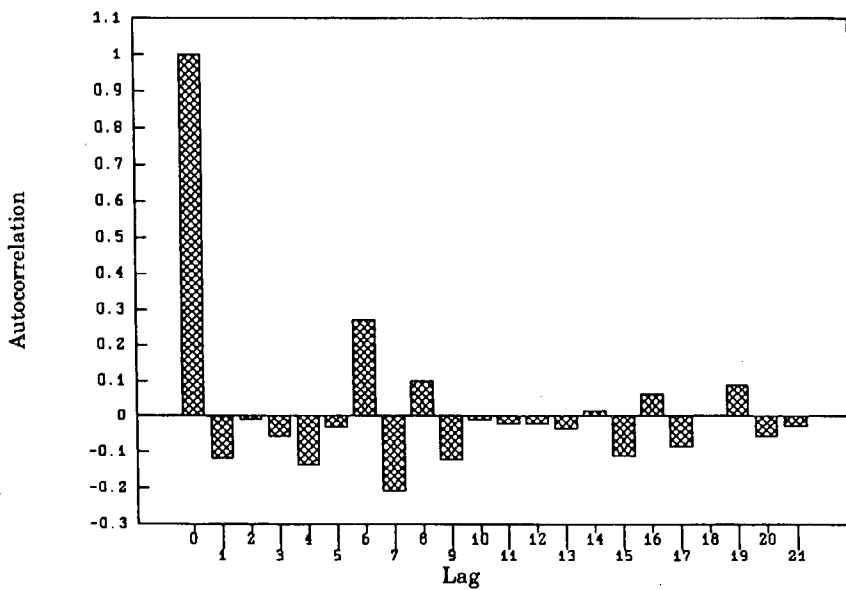Figure 2a: *Autocorrelation Function: Land Prices*

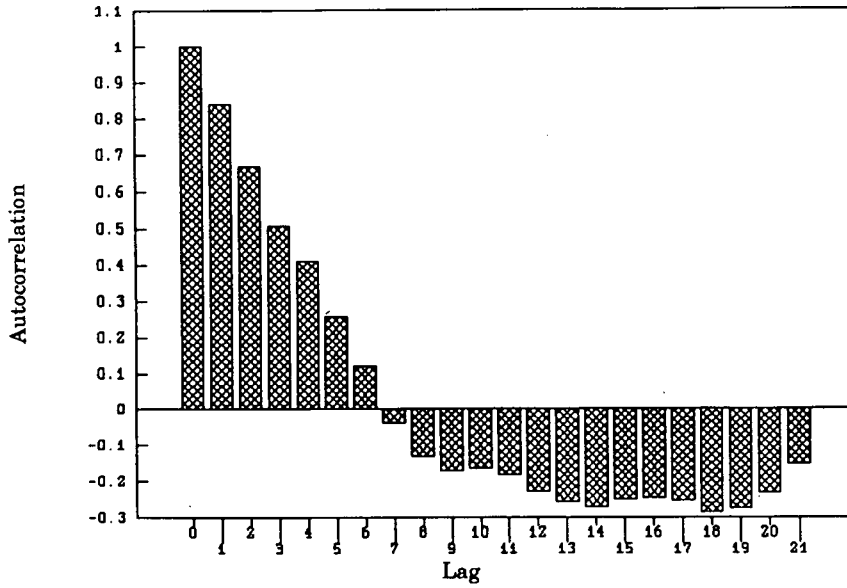Figure 2b: *Autocorrelation Function: Differenced Land Prices*

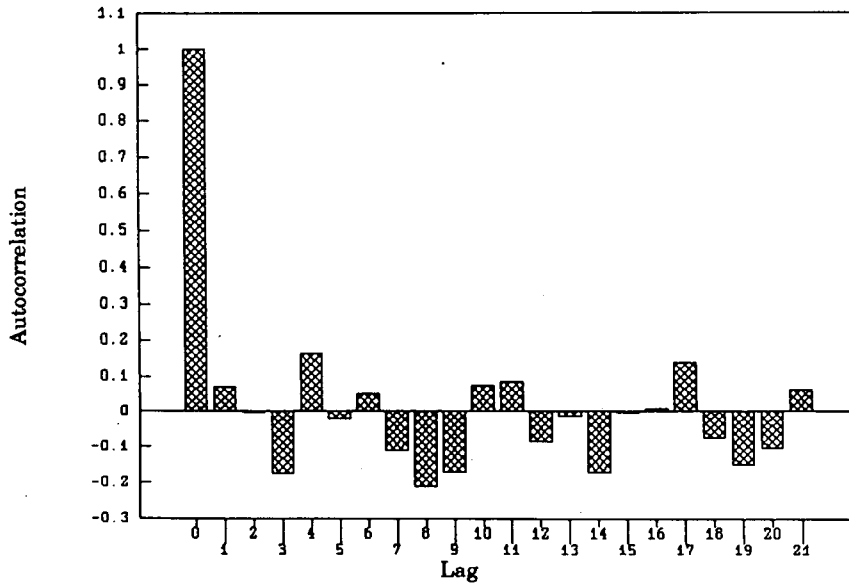Figure 3a: *Autocorrelation Function: Conacre Rent*

Figure 3b: *Autocorrelation Function: Differenced Conacre Rent*

Examination of Column 4 of Table 1 and the lower Q-statistic for whitened differenced price suggests that the uni-variate filter has reduced the price series to white noise.

The autocorrelation function for the differenced rent series given in Table 1 reveals large coefficients at the third and fourth and eighth and ninth lags, suggesting that this series also follows a moving average process. We fitted several uni-variate models to the data and found that an integrated moving average model (0,1,9) gave the best fit. We again estimated the model in general form and then restricted it by constraining insignificant coefficients to zero, yielding:

$$(1 - L)R_t = (1 - .350L^3 - .289L^8 - .192L^9)\hat{\varepsilon}_{2t} \qquad (7)$$
$$(.09) \quad\quad (.10) \quad\quad (.11)$$

$$S.E. = 4.68$$

Column 7 of Table 1 reports the autocorrelation function of the rent residuals after having been passed through the moving average filter given in Equation (7). The autocorrelation coefficients of the whitened series are all fairly small and the Ljung-Box statistic drops to a negligible 3.34.

Turning now to the cross-correlation analysis, which determines direction of causality, Table 1 reports the cross correlation function of the two whitened series. The table yields no evidence of feedback between the two series. Cross correlations between price and lead values of rent are generally small and none are close to statistical significance. The Ljung-Box statistic, at 1.82, is quite small relative to the critical value necessary to reject the hypothesis that no correlation exists between land prices and lead values of rent.

On the other hand, we observe fairly large cross correlations both contemporaneously and at the first, seventh, and ninth lags of rent. All, with the exception of the first lag, are statistically significant.[18] We can say fairly conclusively, therefore, that farm rents, in the Granger sense, cause farm land prices in Limerick. Generally speaking, the cross correlation analysis of the Limerick Auctioneer data suggests that Equation (1) is the appropriate model of the farmland market in this region and that estimation of a transfer function using land price as the dependent variable and rent as the input is valid.

Having established that the relationship between land prices and rents is uni-directional, we next set about the task of estimating a transfer function between the two variables of the general form given in Equation (4). In order

18. The approximate standard error of the cross correlations is $1/\sqrt{n}$, which is .108 in the case at hand.

to do this, we utilised the cross correlation function reported in Table 1 to aid in identification. Experimentation with several different models suggested that the deterministic part of Equation (4) was best represented by a model containing seven numerator parameters and no denominator parameters. Analysis of the residuals of this model, however, revealed that they were characterised to some degree by autocorrelation. We found, ultimately, that the error structure of the model follows a moving average process of order 8. The final transfer function model is:

$$(1 - L)P_t = (18.43 + 12.61L^3 + 12.69L^6 - 13.76L^7)(1 - L)R_t \qquad (8)$$
$$ (4.70) \quad (4.53) \qquad (4.82) \qquad (4.93)$$
$$+ (1 + .384L^6 + .203L^8)\hat{\mu}_{1t}$$
$$ (.116) \quad (.127)$$
$$\text{S.E.} = 206.23 \qquad Q_\mu(10) = 5.96 \qquad Q_{\mu R}(8) - 8.71$$

The transfer function implies that the change in farmland price is significantly related to the change in rent contemporaneously and at the third, sixth, and seventh lags. The model suggests, furthermore, that past forecast errors are directly related to land price change though the effect clearly takes some time to filter through. Because the dependent variable is the annual change in price, Burt interprets this latter effect as the impact that unanticipated capital gains have on land values. Interestingly, anticipated capital gains, as would be reflected by lagged values of the price term in the transfer function, were not statistically significant. Diagnostic checks of the model suggest it is adequate in that its residuals appear to be stationary and non-autocorrelated. Moreover, the Q-statistics of the autocorrelations of the residuals (Q_μ) and of the cross correlations of the residual and rent series ($Q_{\mu R}$) are both quite small.

IV DISCUSSION AND FURTHER ANALYSIS

4.1 *Comparison with Past Results*

The novelty of the results presented above lies not particularly in the time series models themselves. Phipps and Burt, for example, have estimated similar types of models using American data. The interesting aspect of the Irish results emerges when they are compared with these previously estimated models. Our results indicate that innovations in the rent series play particularly persistent roles in determining current farmland value in Ireland. Events occurring up to nine years in the past seem to influence current land price movements. This is in striking contrast to what one finds

in the research that used data on the American farmland market.

The Phipps study, for example, found that farm returns play a signifi-
cant role in determining land price but also found that their effect is much
less persistent than is the case in our model. The general form of·Phipps's
model is:

$$(1-L)P_t = \hat{\beta}R_{t-1} + (1+\hat{\phi}L)\hat{u}_t. \tag{9}$$

Hence, Phipps established that last year's agricultural return plays an
important role in determining current price changes in the American
farmland market, but innovations in returns have no further effect into the
future. Similarly, past forecast errors influence land price, but the effect
persists for only one year, which is relatively short lived compared to the
apparent Irish experience. In general, Phipps's findings are consistent with
the notion that the American land market is very dynamic, incorporating new
information into land prices in rapid fashion.

Burt's model, estimated using a set of data covering a different region in
the US, is:

$$P_t = \frac{(\hat{\beta}_1 + \hat{\beta}_2 L)R_t}{(1 - \hat{\delta}_1 L - \hat{\delta}_2 L^2)} + (\hat{1} + \hat{\phi}L)u_t. \tag{10}$$

This model implies that the adjustment path of land prices in response to an
innovation in rents is a damped cycle. The two American models are,
therefore, at odds with each other to some degree. On the one hand, the
Phipps model suggests that an increment to rent is incorporated into land
price almost immediately. On the other hand, the Burt model implies that the
land market, while incorporating a change in rent into farmland prices fairly
rapidly, tends to over-react to the initial change in income before eventually
settling down to the long run equilibrium.

The dynamics at work in the Irish farmland market differ considerably
from what both Phipps and Burt found to be true in the United States. In the
Irish land market, there are no denominator terms in the transfer function
and therefore there is no tendency for land prices to adjust in the damped
cyclical fashion found in the Burt model. Moreover the numerator (rent)
terms in our transfer function, unlike Phipps's model, are distributed well
back into time.

The question of ultimate import is what factor or factors account for the
difference in the time series processes governing farmland price determin-
ation in the two countries? This is a difficult question to answer. It is
troubling that the price determination process is as apparently as drawn out

as it is in Ireland. One is tempted to cast about for explanations that focus on the inherent competitiveness of the American economy along with the existence of a well-established market for agricultural credit there versus the psychological attachment of Irish farmers to their land and the lack of willingness of the banking sector to lend money for land purchase during much of the twentieth century. Given the nature of time-series analysis, the best one can do is speculate about the relevance and importance of such factors.

We believe a much simpler reconciliation of the two conflicting results exists, however. The distinguishing institutional change that occurred during the period of interest was Ireland's entry into the EEC in 1973. This event had major repercussions for the country as a whole but, particularly, for the farming sector, which gained substantially from price supports administered under the Common Agricultural Policy. In contrast, no such comparable event occurred in the United States during the same period.

Major institutional events and policy changes such as entry into the EEC are referred to in the time series literature as "interventions". (See Box and Tiao, 1975.) Interventions may affect a time series in a variety of ways, possibly shifting its level, changing its trend, or altering its variance. The practical econometric danger of such interventions is that they will contaminate the parameter estimates of models that aspire to explain movements in the time series of interest.

Recall from above that the Limerick land price series passed the stationarity test in that, upon deflation and differencing, the autocorrelation function died out quickly (though it still exhibited some degree of autocorrelation). Examination of a time series plot of differenced land prices (Figure 4) reveals, however, that, though the mean of the series does not change during the period (which is consistent with what the autocorrelation function of the differences is telling us), there are, nevertheless, some rather large swings in the series during the 1970s. Clearly, then, the nature of the price series changed during the period of Ireland's entry into the EEC.

4.2 Analysis of the Pre-EEC Period

In order to assess the impact of Ireland's entry into the EEC on the parameter estimates of the model, we re-estimated the model for the years prior to EEC entry. Because Ireland re-activated its application for EEC membership in 1969, we chose 1968 as the final year of the new sample. Our rationale for this choice is that expectations regarding possible excess profits to be made in landownership due to EEC price supports should begin to matter in 1969, the year of announcement of intent to enter, rather than in 1973, when Ireland officially entered the EEC.
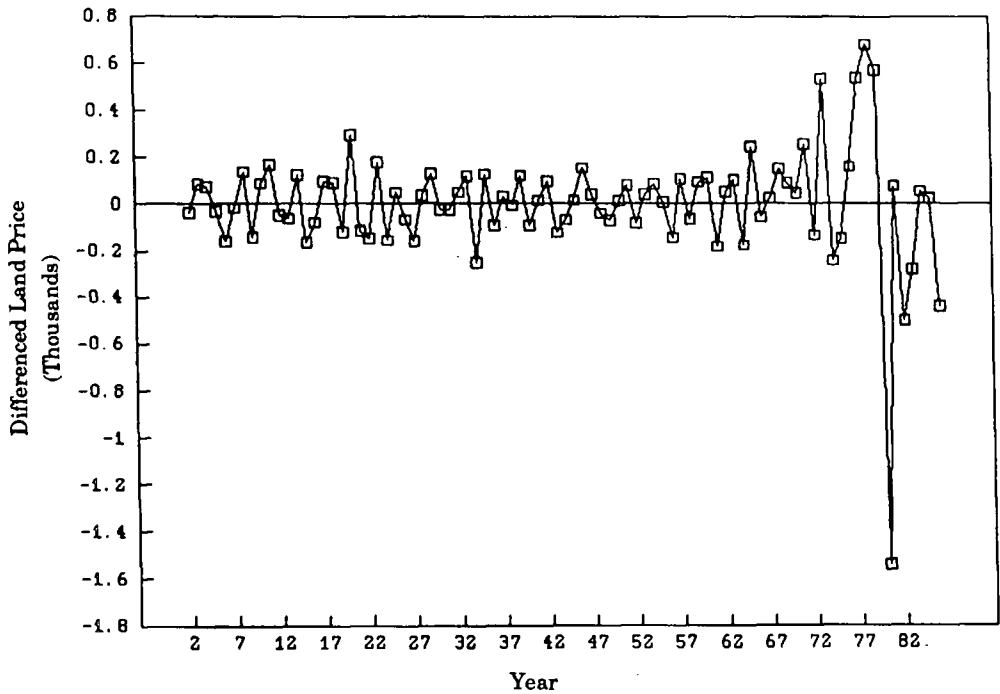
Figure 4: *Differenced Limerick Land Price: 1902-1986*

   Sample autocorrelation functions for differenced price and rent for the period 1901 to 1968 are given in Table 2. Both series appear to be stationary though some residual autocorrelation appears to remain in both. Upon experimentation with a number of different specifications for both series, we arrived at the following two uni-variate models to be used in identifying the appropriate transfer function:

$$(1 + .594L + .419L^2)(1 - L)P_t = \hat{\epsilon}_{3t} \qquad (11)$$
$$ (.115) \quad (.115)$$
$$\text{S.E.} = 95.89$$

$$(1 - L)R_t = (1 - .303L^3 + .305L^4)\hat{\epsilon}_{4t} \qquad (12)$$
$$ (.112) \quad (.112)$$
$$\text{S.E.} = 4.14$$

Table 2: *Auto- and Cross-Correlation Functions: 1901-1968*

	Autocorrelation Functions			
Lag	Differenced Price	Whitened Differenced Price	Differenced Rent	Whitened Differenced Rent
1	−.41	.02	.00	.07
2	−.17	−.04	−.10	−.10
3	.30	−.11	−.26	−.00
4	−.20	−.23	.19	−.03
5	−.13	−.15	−.08	−.15
6	.21	.04	.12	.10
7	−.10	.02	−.00	−.02
8	−.04	.17	−.17	−.14
9	.19	.19	−.07	−.03
10	−.00	.04	.08	.11
11	−.20	−.11	.20	.13
12	.16	.04	−.12	−.11

Differenced Price – Q(6) = 27.87
Whitened Differenced Price – Q(6) = 6.96.
Differenced Rent – Q(6) = 9.69
Whitened Differenced Rent – Q(6) = 8.25

Cross-Correlation Function: Whitened Land Price and Whitened Rent

Lags	CCF	Leads	CCF
0	.25		
1	.06	1	.10
2	.20	2	−.26
3	.10	3	−.18
4	−.04	4	−.06
5	−.16	5	−.03
7	−.10	7	.22
8	.00	8	−.12
9	−.04	9	.10
10	.16	10	.11
11	.06	11	.04
12	.12	12	.26

Leads – Q(6) = 8.27

   Examination of the autocorrelation functions for the two filtered series in Table 2 reveals that both have been reduced to white noise. Both uni-variate models, however, have a markedly different structure than was found for the full period. The rent model is still an MA, but the lag length is considerably shorter than that which was found in Equation (7). The uni-variate model of land price, which is an MA of order 7 when the full sample is used, is AR(2)

when one focuses attention on the period prior to Ireland's entry to the EEC. This result is more consistent with the findings of Burt in particular, and it suggests that a shock to land price is adjusted to in a damped, oscillatory fashion.

We next utilised the residuals from the uni-variate models given in Equations (11) and (12) to construct the cross-correlation function to be used in identification of a suitable transfer function model for the 1901 to 1968 period. Table 2 gives the sample CCF for the two series. Examination of the cross-correlation function reveals one rather large value at the second lead. The Q-statistic is not significant at any of the conventional levels, however. We therefore assume that there is no feedback from price to rent. Looking at the lags of the sample CCF, one observes large values contemporaneously and at the second lag. This finding is in marked contrast to the pattern found in the cross correlations for the full sample, where large cross correlations were distributed well back in time. We experimented with a variety of specifications for the 1901-68 transfer function, but found that the model that yielded the best fit in terms of the Akaike Information Criterion and root mean square error (RMSE) was one with a contemporaneous effect, an effect at the second lag for rent, and an error structure that is AR(2). This result is consistent with the information conveyed in the sample CCF and with the uni-variate model found for price (Equation (11)). The final form of the transfer function for the pre-EEC period in Ireland is:

$$(1 - L)P_t = (4.467 + 3.370L^2)(1 - L)R_t + 1/(1 + .648L + .468L^2)\hat{\mu}_{2t} \quad (13)$$
$$(2.24)\quad(2.10)\,(.117)\quad(.117)$$

$$\text{S.E.} = 92.63 \qquad Q_\mu(10) = 9.46 \qquad Q_{\mu R}(10) = 5.22$$

Several points are worth noting in comparing Equation (13) to Equation (8). First, the lag structure on rent is far shorter than that found when the entire sample is used. This suggests that, at least for the pre-EEC period, changes in the income earning power of the land, as proxied by the rent series, are quickly capitalised into land values. The long run multiplier is 7.837, consistent with a discount rate of 12.8 per cent. This result, then, is very similar to what researchers have found for the US farmland market. Second the appropriate error structure for the period 1901 to 1968 is AR(2) rather than MA(8). This implies that unexpected shocks to land price are adjusted to by the market in a damped, oscillatory fashion. Third, as was true of the model estimated for the full period, no denominator terms appear in the systematic component of the transfer function model, suggesting that anticipated capital gains do not enter directly into the price determination process.

As a final check of the appropriateness of the model given in Equation (13), we re-estimated the model of Equation (8) over the pre-EEC period in order to see whether it could compete closely with equation (13). We found:

$$(1 - L)P_t = (2.335 + 4.574L^3 + 3.553L^6 - 2.822L^7)R_t \qquad (14)$$
$$(3.65) \quad (3.82) \qquad (3.57) \qquad (3.42)$$

$$+ (1 + .249L^6 + .035L^8)\hat{\mu}_{3t}$$
$$(.146) \qquad (.148)$$

$$\text{S.E.} = 117.090 \qquad Q_\mu(10) = 30.65 \qquad Q_{\mu R}(8) = 8.45$$

Thus, the transfer function identified for the entire sample performs quite poorly when fitted to only the pre-EEC years. Only one of the parameter estimates is statistically significant at a conventional level and that is in the error term. Moreover, the RMSE of Equation (14) is more than 26 per cent larger than that of Equation (13) and the Q-statistic for autocorrelation in the residuals is statistically significant, indicating inadequacy in the model's noise structure.

4.3 *Intervention Analysis of the EEC Years*

In order to determine how the transfer function specified for the pre-1969 period would perform in the years after Ireland's announcement of intent to enter and subsequent entry into the EEC, we examined how the model of Equation (13) tracked actual land prices from 1969 to 1986. Thus, we calculated the one-step ahead predictions using Equation (13) and the actual values of conacre rent observed in the post-1968 years. These predictions were plotted against the observed values of land price. Figure 5 presents the results of this exercise.

Figure 5 shows that the model fitted through 1968 tracks Limerick land prices up to and through 1968 quite well, as one would expect. After 1968, upon Ireland's announcement of desire to enter the EEC and its subsequent entry in 1973, one observes a steady divergence of land value from what the present value model of land valuation would predict on the basis of the underlying income earning ability of the land. Notably, the difference between observed land prices and predicted land prices reaches its peak in 1979 and diminishes thereafter until the model appears to be back on target by 1983.

The finance literature refers to such a divergence from market fundamentals as a "rational bubble". Specifically, West (1988, p. 648) defines a rational bubble as "an otherwise *extraneous event* (our italics) that affects stock prices because everyone expects it to do so." Diba and Grossman (1988,
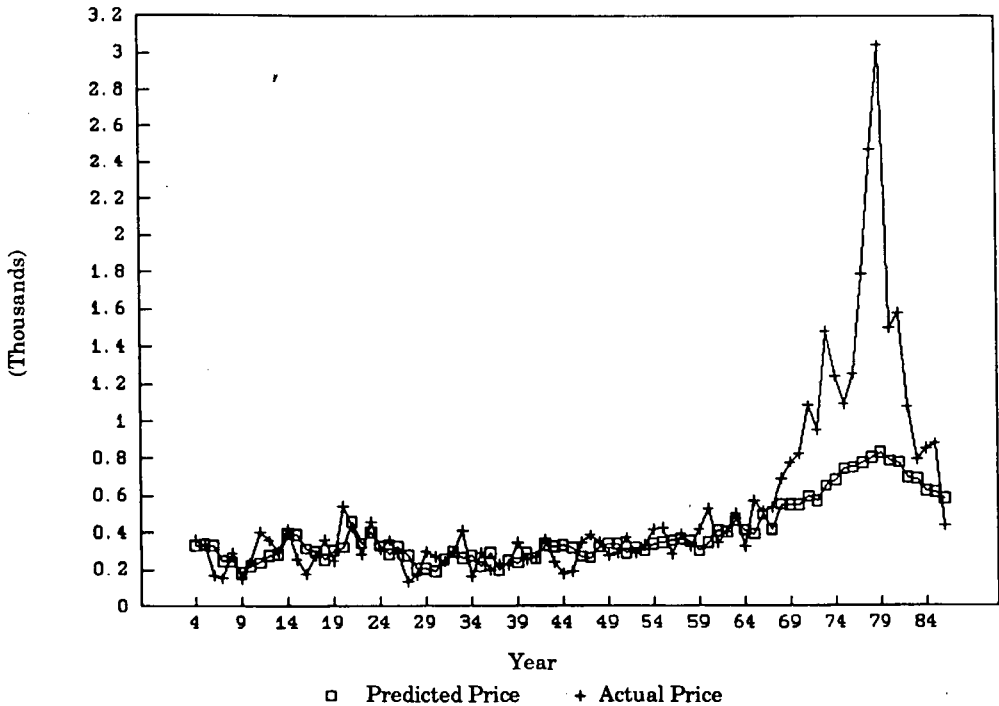
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Figure 5: *Actual and Predicted Values (Equation 13) of Land Price*

p. 520) note that, "A rational bubble reflects a self-confirming belief that an asset's price depends on a variable (or a combination of variables) that is intrinsically irrelevant – that is, not part of market fundamentals — or on truly relevant variables in a way that involves parameters that are not part of market fundamentals." Clearly, EEC entry and its effect on the farming sector fall into the latter category in that, because of the transition to significantly higher levels of agricultural price supports, farmers in Ireland reaped windfall profits for a period of time. When land prices collapsed in the early 1980s the bubble burst.

The swift turnaround in land prices that took place in Ireland in the early 1980s also occurred in other countries, such as the US and elsewhere in the EEC, which, likewise, had experienced accelerated growth in land prices in the 1970s. Reasons given for the fall in prices include higher operating costs, rising real interest rates, declining product prices, the debt burden accumulated by farmers during the booming seventies, and lower expectations with respect to inflation (Scott, 1983). In EEC countries, the rising cost of surplus agricultural production brought about a reappraisal of

agricultural support policies suggesting the possibility of lower real prices for agricultural products.[19]

In order to ascertain whether the type of transfer function model fitted through 1968, i.e., a transfer function of order 2 in the numerator with an AR(2) noise structure, would explain Limerick land prices adequately upon taking the intervention effects of EEC entry and membership into account, we next conducted an intervention analysis. In modelling intervention effects, the analyst has several options available. For example, one could treat the announcement of intent to enter the EEC as the intervention and then look at the dynamic effect this intervention has on land prices. In the case at hand, this type of intervention implies a gradual, but steadily increasing, effect, followed ultimately by an ebbing away of the reaction to the intervention. We estimated this type of model and indeed got reasonable results, but the intuition here is lacking. In other words, it seems highly unlikely that what is occurring in the farmland market in, say, 1979 is a reaction to an announcement that took place in 1969. Rather, one would logically expect that what is going on in 1979 is itself a response to the policy decisions of the EEC and the CAP in that particular year. Indeed, historical accounts, such as Lee's, give one a definite sense that CAP policy is very fluid during this period, with price supports steadily increasing to unprecedented heights by 1979 and falling thereafter. In this context, then, it is more sensible to regard any given year as deserving of an intervention effect in its own right.

The time series literature refers to this latter type of intervention as a "pulse" intervention, defined as:

$$\xi_t = \begin{cases} 1 \text{ for year t} \\ 0 \text{ otherwise} \end{cases}$$

We re-ran the transfer function model of Equation (13) for the entire 1901-1986 period, but we also included a series of pulse interventions for the years 1969 through 1981 — the period of announcement of intent to enter, official entry, and subsequent adjustment to EEC entry. The estimated transfer function that results when EEC interventions are included is remarkably similar to Equation (13). It is:

19. Lee (1989), pp. 490-491, discusses the period from 1976 and onward, wherein he notes that "... farmers revelled in the largesse of the CAP" and that FEOGA guarantees increased from 102.2 million pounds in 1976 to 381.1 million pounds in 1979, after which CAP supports were contained. Also see Varela-Ortega (1987) on the attentuation of CAP price supports after 1979.

$$(1 - L)P_t = (5.578 + 5.471L^2)R_t + 1/(1 + .706L + .538L^2)\hat{\mu}_{4t} \qquad (15)$$
$$(2.29) \quad (2.12) \qquad\qquad (0.120) \; (0.121)$$
$$\text{S.E.} = 101.57 \qquad Q_\mu(10) = 7.00 \qquad Q_{\mu R}(10) = 6.24$$

Several points are worth making regarding Equation (15). First, the parameter estimates of the numerator terms on the input variable and of the AR structure of the error term are very close to those found in Equation (13), which utilised only the data up to and including 1968. Second, the RMSE found in the pre-EEC model and the model which allows for intervention effects due to EEC entry, at 92.63 and 101.57 respectively, are very close to each other despite the turbulence in the market for land purchase over the last 18 years of the sample. Finally, the intervention model of Equation (15) does a much better job of accounting for variation in land prices than does the full-sample transfer function presented in Equation (8). We base this observation again on comparison of the root mean square errors, with the RMSE more than twice as large in Equation (8) than in Equation (15). So while Equation (8) is an adequate representation of the behaviour of land prices when the usual diagnostic checks are applied, it is clearly encompassed by Equation (15), which has a lower RMSE and a comparable structure to that found prior to the market excesses of the 1970s.

Figures 6a and 6b plot actual land prices and the one-step-ahead predictions from the models in Equations (8) and (15), respectively. Visual comparison of the pictures shows that the transfer function model of Equation (15), which takes the interventions into account, tracks the movement of land prices extremely well relative to a transfer function model which does not allow for the intervention effects of EEC entry.
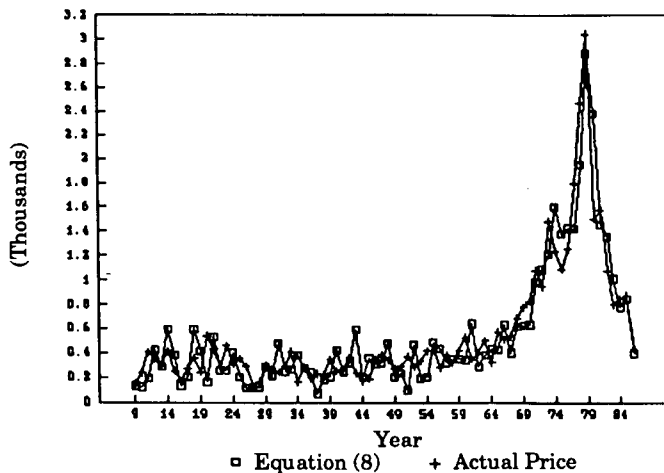

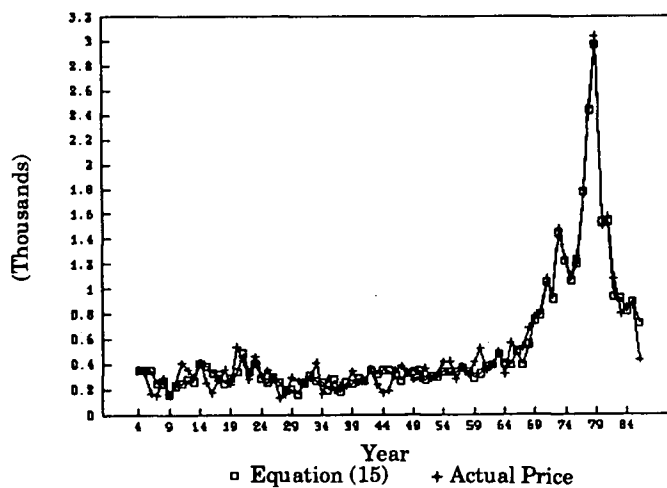Figure 6a: *Actual and Predicted Land Prices, 1901-1986, using Equation (8)*

Figure 6b: *Actual and Predicted Land Prices, 1901-1986, using Equation (15)*
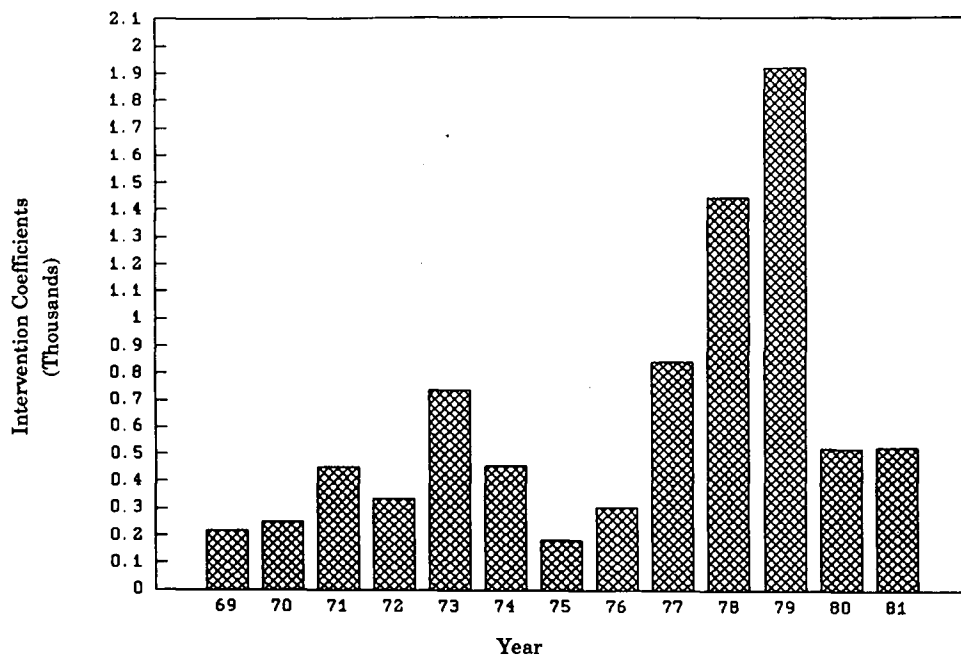

Figure 7: *Estimated Intervention Coefficients, 1969-1981*

We present a graphical depiction of the estimated interventions in Figure 7. All of the interventions were highly significant with the exception of 1975, which was significant at the 10 per cent level.[20] The pattern found in Figure 7 is sensible in light of the historical facts of the period. One sees rising estimated values up to the year of official entry into the EEC, followed by two years in which land price is only marginally higher than that which would be expected on the basis of market fundamentals. From 1976 to 1979, the interventions suggest land prices well above that which would be expected on the basis of the present value model. Recall that 1979 is the year in which Brussels decided to put a halt to what had been ever-increasing agricultural price supports. Finally, in 1980 and 1981 the effect of EEC entry diminishes, after which land prices return to levels that would be expected on the basis of market fundamentals alone.

V CONCLUSION

This paper models the dynamic link between farmland prices in Ireland and a measure of farm returns, conacre rents. The standard theory of the firm suggests that farmland value is the sum of the discounted expected future net return accruing to the land. If expectations of net returns are generated by past behaviour of net returns, then land value should in turn be determined by the past behaviour of net returns.

Using data spanning the years 1901 to 1986, our initial results suggested that the relationship between land prices and rents is considerably different in Ireland than that which other researchers using similar methodology have found to be the case in the United States. Specifically, the initial results indicated that a change in rent affects the level of land prices well into the future in Ireland. One possible explanation for the slow adjustment process is that the Irish economy, given its dependence on agriculture and its unique historical circumstances, possesses key structural differences *vis-à-vis* other countries which account for the slow adjustment process. Further empirical analysis suggests, however, that Irish entry into the EEC disturbed the price time series to such a degree that the initial model is mis-specified and incorrect. Re-estimation of the model using data from the period prior to Ireland's announcement of intent to enter the EEC yields a structure quite similar to what researchers have found to be the case elsewhere. Specifically a change in rent is rapidly capitalised into farmland values in Ireland, and

20. We also investigated the possibility that EEC entry continued to have repercussions after 1981. However, no outliers were detected in the post-1981 period; all interventions after this point, therefore, were not statistically significant.

shocks to land prices are adjusted to in a damped, oscillatory fashion. Extension of this model to the post-1968 period, upon proper allowance for the intervention effects of EEC entry, produces strikingly similar results.

In closing, we wish to make three points. First, we find the transmission process between the income earning ability of the land and the value of the land to be fairly direct and rapid in Ireland. Furthermore, this transmission process accords well with what researchers have found to be the case elsewhere.

Second, EEC entry has a very interesting impact on land prices in Ireland. Our results suggest that the impact resulted in sizeable increases in land prices for some period of time not only during the entry process but also subsequent to official entry. Behaviour of land prices during the period after official entry coincides closely with CAP policies of the time.

Finally, an interesting issue for future research concerns the intervention effects themselves. Specifically, we wonder whether the observed bubble in Irish land prices is attributable to the institutional event of EEC entry and the subsequent access and adjustment to agricultural price support programmes, or is it the case that the divergence from market fundamentals observed in Ireland during the 1970s was also experienced by long-standing members of the EEC during the same period?

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