Speculation in Agricultural Land*

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Summary

Agricultural land prices in many developed countries rose and then fell dramatically over a relatively short period of time in the late 1970s and early 1980s. Most of the models in the literature that describe the dynamic behaviour of agricultural land prices suggest that these sharp price movements were not completely due to market fundamentals. Many attribute part of this price volatility to speculation. This phenomenon is investigated by estimating a general regime-switching model that nests many types of speculative behaviour as special cases. We find strong evidence to support a partially collapsing bubbles story about Irish agricultural land prices.

Keywords: speculation, fads, bubbles, farmland prices

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1. Introduction

The relationship between the factors that affect the monetary returns to agricultural land and real land values has attracted considerable attention in agricultural economic literature (see for example Lloyd and Rayner, 1990; Hallam, Machado and Rapsomanikis, 1992; Browne and Fagan, 1992; Weliwita and Govindasamy, 1997; Engsted, 1998; Falk and Lee, 1998; Lence and Miller, 1999). While most of these studies have been primarily concerned with the fundamental price of agricultural land, some research has focused on speculative behaviour in farmland prices. For example; Browne and Fagan (1992) use cointegration techniques and Murphy and Nunan (1993) use transfer function analysis on agricultural land prices in Ireland, Lloyd (1993) used intervention analysis on land prices in the United Kingdom, and Falk and Lee (1998) use a structural vector autoregression to investigate farmland prices in the United States. Although these studies were for different countries and employed different statistical techniques, all of their results show that the dynamic response of land prices is consistent with a hypothesis of speculative behaviour. However some have suggested that the speculative behaviour was due to fads, while others suggested that it was due to bubbles. In this paper we estimate a regime-switching model, that encompasses both of these phenomenon, to investigate what type of speculative behaviour, if any, was present in agricultural land prices.

As an illustration of the regime-switching statistical techniques we use annual Irish data for the period 1911-96[1]. By many accounts there appeared to be a boom and bust cycle in Irish agricultural land prices the late 1970s and early 1980s (see for example Murphy and Nunan (1993)). In Section 2 we describe different types of land price series available in Ireland and examine key trends in agricultural prices and output.

While there are many types of speculative behaviour that cause actual asset prices to deviate away from market fundamental values, the fads model developed by Summers (1986) and the

stochastic bubbles model proposed by Blanchard and Watson (1982) are often cited in the literature. van Norden (1996) suggested that regime-switching statistical techniques could be employed to test not only these fads and bubbles models but also a variety of other models of non-fundamental price behaviour. In Section 3 we discuss these theoretical regime-switching models of speculative behaviour.

The regime-switching model requires estimates of non-fundamental agricultural land prices, which we define as the difference between the actual price of farmland and its fundamental value. However there is no unique economic model of the market fundamentals and this has led to much argument over the correct model of farmland prices. See for example the Lloyd and Rayner (1993) and Hallam (1993) debate over models of agricultural land prices in the United Kingdom and statistical tests of various of models using data from the United States performed by Weliwita and Govindasamy (1997). In Section 4 we estimate four models of fundamental (and thus non-fundamental) agricultural land prices. The correlations between the four estimates of non-fundamental farmland prices are remarkably high. All of these models suggest that Irish agricultural land prices were increasingly overvalued in the late 1970s.

The results from estimating a general regime-switching model of real agricultural land prices are presented in Section 5. This model relates the response of the change in agricultural land prices to the previous year's non-fundamental price. Our main findings suggest that no matter which of the four economic models are used to generate the market fundamentals, there is strong evidence that there was a speculative bubble in farmland prices in the late 1970s. We estimate that the probability of a crash reached its highest value in 1979, the year before prices started to fall rapidly. A final section offers conclusions and a discussion on the current rise in farmland prices.

2. Irish agricultural land price data

One of the main recommendations of a report by O'Conner and Conlon (1993) was the provision of an official Irish agricultural land price series. The absence of an official Irish agricultural land price series until 1996[2] has provoked certain comment and innovation on the part of researchers interested in the area. Before 1996 in order to obtain a long historical land price series some economists compiled their own data. Kelly (1981) outlined three series used by Teagasc[3] in an analysis of the price of land in the 1970s. The first was a series compiled from a sample of farmers who participated in Teagasc's Farm Management Survey in 1977. Farmers were asked to provide information on the price of land and the area of land that they had purchased since 1950. A second series, which has been frequently used for evaluation of historical land price movements has been data provided by the Irish Land Commission (ILC). The ILC, a rent-fixing body, was a significant purchaser and distributor of land and was used to implement a structural reform programme on a countrywide basis. Its activities were scaled down following the government's decision to abolish it in 1984. The third price series examined by Kelly (1981) was acquired from six firms of auctioneers who were sampled by Teagasc between the years 1970 and 1980. Kelly (1981) concluded, "there was relatively good agreement" between the three price series. Barrett and Trace (1999) in an evaluation of the impact of agricultural and forestry subsidies on land prices in Ireland updated the data contained in O'Conner and Conlon (1993) by examining information contained in the 'particulars delivered forms' from the Valuation Office records.

Nunan (1987) produced data on both land prices and conacre rent payments for the Limerick area (Co. Limerick, south Co. Clare and west Co. Tipperary) from 1901 to 1986. The series was subsequently updated to 1996 (see Appendix 1 for a discussion on the data sources). The attraction of the Limerick data lies both in the length of the time series provided as well as the information on the conacre rents. Nunan (1987) also compared both

the levels and trends of the Limerick series with both the ILC series and the survey data compiled by Teagasc. In doing so the representativeness of the Limerick series from a national perspective can be gauged. In comparing the ILC series and the Limerick series, Nunan (1987) concludes that both series are "reasonably close over the long term". While both the auctioneer and ILC land price are both highly correlated the latter series are only available for a shorter time period and may not have been influenced by market forces as much. For these reasons we use the data for the Limerick region in our analysis.

2.1 *Why the boom in the 1970s*

Irish land prices, in both nominal and real terms, escalated quite significantly in the 1970s. We present real agricultural land prices in Figure 1 for the period 1911-96. This is the Limerick farmland price divided by the consumer price index (see Appendix 1). It is evident that there was a very sharp rise in prices in the late 1970s, peaking in 1979. Real farmland prices increased by 167% between 1975-79 and then fell by 82% between 1979-86[4].

INSERT FIGURE 1 ABOUT HERE

One of the more standard arguments put forward in the examination of agricultural land prices is that the price of land is directly related to the marginal revenue product of land, i.e. agricultural output prices and income levels. During the period 1966 to 1979 there was a substantial rise in Irish agricultural price and income levels. This was primarily due the Irish accession to the EEC in 1973. A summary of the price and income level increases is reported in the Tables 1 and 2 below.

INSERT TABLES 1 AND 2 ABOUT HERE.

Prices of all items of agricultural output increased dramatically between 1968 and 1977. Whilst nominal prices increased by substantial amounts for the period, real prices also witnessed sizeable growth. This real growth is in contrast to the depressed nature of real prices between 1960 and 1968. Table 2 presents a summary of growth in family farm income for both Ireland and Limerick. Income per male on the farm is also included.[5] Growth patterns in the Limerick area are broadly in line with national trends.

During the 1968-1977 time period there were also some setbacks to economic growth for the farming community. There was a cattle crisis in 1974 when poor grass growth earlier in the year precipitated a state of panic in the autumn. Following the 1973 oil price shock input prices increased by some forty per cent in 1974, which exacerbated the cattle crisis. So the significant growth in income levels for the same period is all the more remarkable.

The buoyancy in farming during the 1970s is further highlighted by trends in farm mechanisation for the period. The common theory of higher prices being bid into capital values such as agricultural land is reinforced by the increased investment undertaken by the farming community. The growth rates in Irish farm mechanisation are presented in Table 3. Note in particular the dramatic increase in the number of milking parlours from 8,200 in 1970 to 19,500 in 1975. This rapid change in technology could be perceived as evidence of heightened producer expectations in the sector.

INSERT TABLE 3 ABOUT HERE.

The picture emerging for the agricultural sector between 1970 and 1980 is one of expansion. Prices in both nominal and real terms were increasing substantially, as were family farm income levels. Producers' expectations were never so high, as the increased

levels of farm mechanisation during the 1970s suggest. Land as a fixed input was therefore in much demand throughout the 1970s as producers sought to avail of the increased price levels. Even with the significant increase in prices and incomes, Nunan (1987) graphically demonstrates that the price of land in the 1970s still outstripped the price of Irish agricultural produce.[6] Thus one can argue that the rate of growth in agricultural prices and incomes between 1970 and 1980 was such as to generate a bubble in land price expectations. We investigate this further in Section 4.

3. A regime-switching model for agricultural land prices

We assume that the price of agricultural land, P_t, can be decomposed into two parts, a market driven fundamental price, P_t^f, and a speculative non-fundamental price, P_t^{nf}. The non-fundamental price is any deviation of the actual price away from its market fundamental price. We consider three types of dynamic behaviour in non-fundamental farmland prices. If the non-fundamental price behaves in a random fashion then on average agricultural land prices will reflect market values. However, land developers, investors and farmers can speculate and react to factors unrelated to fundamentals. In this case certain dynamic patterns will be present in the non-fundamental price. Non-fundamental prices are said to be following a "fad" (see for example Summers, 1986) if we observe agricultural land prices that are temporarily above (or below) the market value for long periods of time but eventually revert to that market value. Alternatively, the anticipation of rising farmland prices induces more market participants in the pursuit of short-term capital gains. Movements in agricultural land prices reflect this behaviour and become self-fulfilling prophecies of speculators. A non-fundamental price that behaves in this way is often called a "speculative bubble" (see for example Blanchard and Watson, 1982).

The following regime-switching model developed by van Norden (1996) nests all three types of behaviour of the non-fundamental price. It extends the stochastic bubbles model of Blanchard and Watson (1982). The model assumes[7]

(i) that there are two states of nature, one a high variance (bad, crash) state, C, and the other a low variance (good, survival) state, S;

(ii) that the non-fundamental price may either survive (collapse) with a probability q (1-q);

(iii) that the probability of the non-fundamental price's continued growth falls as the non-fundamental price grows and;

(iv) that the non-fundamental price is expected to partially collapse in state C where the expected size of the collapse depends on the relative size of the non-fundamental price to the fundamental market price.

The general regime-switching regression model is given by

$$\Delta P_{t+1} = \beta_{S0} + \beta_{S1} P_t^{nf} + \eta_{t+1}, \quad \eta_t \sim N(0, \sigma_s^2) \text{ with a probability of } q, \tag{1}$$

$$\Delta P_{t+1} = \beta_{C0} + \beta_{C1} P_t^{nf} + \eta_{t+1}, \quad \eta_t \sim N(0, \sigma_c^2) \text{ with a probability of } 1-q, \tag{2}$$

and

$$Prob\left(State_{t+1} = S\right) = q\left(P_t^{nf}\right) = \Phi\left(\beta_{q0} + \beta_{q1}\left(P_t^{nf}\right)^2\right). \tag{3}$$

The probability of the bubble surviving is bounded between 0 and 1 using the Logit function $\Phi(\bullet)$. Since we have assumed that the errors generating returns have normal, independent and identical distributions, the loglikelihood function for the general regime-switching model is given by

$$\sum_{t=1}^{T} ln \left[\begin{array}{l} \left(1 - \dfrac{1}{1+e^{-\left(\beta_{q0}+\beta_{q1}(P_t^{nf})^2\right)}}\right) \bullet \dfrac{\varphi\left(\dfrac{\Delta P_{t+1} - \beta_{C0} - \beta_{C1} P_t^{nf}}{\sigma_C}\right)}{\sigma_C} \\ + \left(\dfrac{1}{1+e^{-\left(\beta_{q0}+\beta_{q1}(P_t^{nf})^2\right)}}\right) \bullet \dfrac{\varphi\left(\dfrac{\Delta P_{t+1} - \beta_{S0} - \beta_{S1} P_t^{nf}}{\sigma_S}\right)}{\sigma_S} \end{array} \right], \tag{4}$$

where φ is the standard normal probability density function[8].

If $\beta_{S1}=\beta_{C1}=\beta_{q1}=0$ then farmland prices fluctuate around their market values in a random fashion. In this case the errors generating returns are assumed to be from a mixture of normal distributions with different means and variances. van Norden (1996) labels this the mixture normal model. If $\beta_{S0}=\beta_{C0}$, $\beta_{S1}=\beta_{C1}<0$, and $\beta_{q1}=0$ then non-fundamental agricultural land prices are mean reverting as in the fads model. Note Cutler, Poterba and Summers (1991) test a fads model by estimating a simple linear regression model that uses the non-fundamental price to predict future changes in the price. When this model is estimated one typically finds a significant negative coefficient on the non-fundamental price as the fads model predicts. However the residuals are usually found to be heteroscedastic[9]. Thus in (1) and (2) van Norden (1996) assumes a special type of heteroscedastic error term distribution that depends on the regime. In this way the general regime-switching model nests the fads models.

The general regime-switching model only allows the model to be identified up to a renaming of parameters (i.e. one could swap the names of the regimes). Therefore van Norden (1996) shows that the bubbles model imposes the following restrictions on the general regime-switching model: either $\beta_{S0}\neq\beta_{C0}$, $\beta_{S1}>0>\beta_{C1}$, and $\beta_{q1}>0$ or $\beta_{S0}\neq\beta_{C0}$, $\beta_{S1}<0<\beta_{C1}$, and $\beta_{q1}<0$. Note general regime-switching model nests the bubbles model that in turn nests both the fads and mixture normal models as special cases. In Section 5 all of these restrictions are tested using likelihood ratio tests. We also estimate versions of these models that assume that there is a constant probability of survival by setting $\beta_{q1}=0$.

4. Models of fundamental agricultural land prices

For most assets there is no unique model for the value of market fundamentals; agricultural land is no different. There have been many models of fundamental farmland prices proposed in the literature (see for example Lloyd and Rayner, 1990; Hallam, Machado and

Rapsomanikis, 1992; Weliwita and Govindasamy, 1997; and Engsted, 1998). In general a proxy is used to measure the fundamental price and thus the non-fundamental price. Such a proxy is likely to be measured with error. However, misspecifying either the level or the scale of the non-fundamental agricultural land price will have no effect on the regime-switching tests, as the coefficient restrictions and likelihood ratio tests discussed in Section 3 are invariant to linear transformations of the non-fundamental price. What is required is an estimate of the non-fundamental farmland price that is highly correlated with the true value. In this section we discuss four possible models for proxying the fundamental agriculture land price.

In the last decade the constant-discount-rate present-value-model has been widely used to study farmland prices (see for example Lloyd, Rayner and Orme, 1991; Browne and Fagan, 1992; Murphy and Nunan, 1993; Engsted, 1998; and Lence and Miller, 1999). In its simplest form this model assumes that the real price of farmland is linearly related to real farmland rents. Thus we estimate the following log-linear relationship between real farmland price, p_t, and real rent per acre, r_t

$$\underset{(3.50)}{p_t = 3.71} + \underset{(3.23)}{0.77 r_t}, \tag{5}$$

where the absolute t-statistics are in parenthesis. The coefficient on real farmland rents has the correct sign.

Browne and Fagan (1992) assume that both series are non-stationary integrated processes and that they may be cointegrated with each other. They and many others interpret cointegration as lack of evidence of a speculative bubble. However this interpretation may be incorrect as Evans (1991) has shown that the stationarity tests over-reject the presence of bubbles even when a bubble exists by construction. In addition, van Norden and Vigfusson

(1996) have shown that their bubbles tests using regime-switching models have better finite sample properties than tests based on the cointegration methodology

In Table 4 we present augmented Dickey and Fuller (1981), Phillips and Perron (1988) and Zivot and Andrews (1992) unit root tests for the all the logged variables used in the four models for proxying the fundamental agriculture land price[10]. The number of lags in the augmented Dickey-Fuller tests is determined by a t-statistic greater than 1.64 on the last coefficient on the lagged changes of the series in the test regression. The Dickey-Fuller and Phillips-Perron test regressions included a constant, as there was no perceivable trend in each series (with the exception of real agricultural output where a trend was included in the test regression). The Zivot and Andrews (1992) tests assume a unit root null hypothesis versus the alternative hypothesis that the series is stationary around a break in its level (Test A), a break its growth rate (Test B) and a break in both its level and growth rate (Test C). It is evident from these tests that real farmland price and real rent per acre are both non-stationary.

INSERT TABLE 4 ABOUT HERE

We use the residual from (5) as our first estimate of the non-fundamental farmland price and label this Method A. However, we note that Flood and Hodrick (1990) have demonstrated that evidence of behaviour predicted by a speculative bubble is not definitive proof that a bubble exists. If there was regime-switching in the economic model describing market fundamentals, then this would be observationally equivalent to the regime-switching model motivated by bubbles that was discussed in Section 3. One might argue that the very sharp rise in farmland prices over the 1975-79 period (see Figure 1) was due to a sharp change in market fundamentals. To examine this issue we carried out parameter stability tests on (5). Hansen (1991) has developed a test for a swift change in the cointegrating

relationship. The p-value for Hansen's SupF test for equation (5) is 0.17. This suggests that regime-switching in fundamentals was not an important contributor to the sharp rise in farmland prices in the late 1970s.

As an alternative model we employ a time varying-discount-rate present-value-model of Falk and Lee (1998) to study the dynamics of agricultural land prices. They assume that fundamental and non-fundamental prices of farmland can be estimated using a vector autoregression (VAR) model comprised of three stationary variables.[11] The variables (logged) they use are the change in rents Δr_t, the change in rents less the real interest rate $\Delta r_t - i_t$ and the spread between price and rent $p_t - r_t$ (see Appendix 1). The unit root tests that are reported in Table 4 suggest that these variables are stationary. The following vector moving representation (VMA) is estimated

$$\begin{bmatrix} \Delta r_t \\ \Delta r_t - i_t \\ p_t - r_t \end{bmatrix} = C(L) \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix}, \tag{6}$$

where L is the lag operator, $C(L)$ are matrices of coefficients and ε_{it} are independently and identically distributed structural shocks with a zero-mean.

Falk and Lee (1998) impose structural restrictions to identify three types of shocks. They identify ε_{1t} as a permanent fundamental innovation (for example, breakthroughs in crop genetics), ε_{2t} as a temporary fundamental innovation (for example, unusual changes in the weather), and ε_{3t} as the non-fundamental innovation (for example, speculation). In Table 5 we present the Akaike and Schwartz information criteria for VAR models using up to four lags. These criteria gave inconclusive results so we performed standard likelihood ratio tests where the restricted model contained only one lag. The p-values are presented in the final column. The evidence suggests that one lag in the VAR is appropriate. Once the VMA is estimated one can historically decompose the actual real farmland price series into the three

components[12]. We use the historical non-fundamental component as an estimate of the non-fundamental farmland price and label this Method B.

INSERT TABLE 5 ABOUT HERE

The third measure of the fundamental farmland price is based on an inverted demand equation for agricultural land. Variants of this model have been estimated by many (see for example, Traill, 1979; Harvey, 1989; Hallam, Machado and Rapsomanikis, 1992; Weliwita and Govindasamy, 1997). We assume that the real price of farmland is related to the logarithm of real agricultural output[13], y_t, real interest rates, i_t, and a trend dummy, t (see Appendix 1). The trend dummy is intended to capture changes in technology. The unit root tests reported in Table 4 suggest that these variables are non-stationary. The coefficient on the trend dummy was insignificant in our initial estimated equation as it is highly correlated with the output variable. Thus we estimated the following log-linear fundamental relationship between real farmland price, real agricultural output and the real interest rate

$$\underset{}{p_t} = \underset{(93.50)}{7.97} + \underset{(11.60)}{0.44 y_t} - \underset{(1.40)}{1.02 i_t}, \qquad (7)$$

where the absolute t-statistics are in parenthesis. The coefficients on the real output and real interest rate variables have the correct sign. The p-value for Hansen's SupF test for equation (7) is 0.13. This suggests that regime-switching in fundamentals was not an important contributor to the sharp rise and fall in farmland prices around 1979 (see Figure 1). We use the residual from (7) as our third estimate of the non-fundamental price and label this Method C.

Murphy and Nunan (1993) suggest that there may have been a bubble in Irish land prices in the late 1970s and that one reason may have been the higher agricultural output prices due to EEC membership. Our final measure of the fundamental farmland price is based on a

simple assumption that the real price of farmland is related to logarithm of real agricultural output prices, ap_t, and a trend dummy to capture changes in technology (see Appendix 1). The unit root tests that are reported in Table 4 suggest that the real agricultural output price is non-stationary. We estimated the following log-linear fundamental relationship between the real farmland price and the real agricultural output price

$$\underset{}{p_t} = \underset{(21.33)}{5.05} + \underset{(11.55)}{0.026t} + \underset{(4.99)}{1.23ap_t}, \tag{8}$$

where the absolute t-statistics are in parenthesis. The coefficients on the real agricultural output price have the correct sign. The p-value for Hansen's SupF test for equation (8) is 0.03. This suggests that regime-switching in the market fundamentals in this model may have been an important contributor to the sharp rise in farmland prices in the late 1970s. However, bearing this in mind, we use the residual from (8) as our final estimate of the non-fundamental price and label this Method D.

We present all four estimates of the non-fundamental farmland price in Figure 2. All four measures appear to be highly correlated. Land prices tended to be increasingly overvalued in the late 1970s. These measures are similar to the results presented by Murphy and Nunan (1993) that use a transfer function model to estimate fundamental farmland prices.

INSERT FIGURE 2 HERE

5. Empirical results

We estimate four versions of the regime-switching model (4) using data on returns from investing in agricultural and the four different estimates of non-fundamental farmland prices presented in the last section. The results for Methods A to D are presented in Table 6. The analysis of the results is comprised of the following five stages

(i) the estimated general regime-switching model is tested for possible misspecification;

(ii) if the model is not seriously misspecified likelihood ratio statistics are used to test the general regime-switching model against the fads and mixture normal models;

(iii) if the general regime-switching model is not rejected Wald statistics are used to test the parameter restrictions on the general regime-switching model implied by the bubbles model;

(iv) we also test whether the estimated slope coefficients of the general regime-switching model are significant and have the correct sign predicted by the bubbles model;

(v) finally if the results are supportive of the bubbles model we present an historical account on farmland price movements.

INSERT TABLE 6 ABOUT HERE

The misspecification tests performed on (4) are for serial correlated and ARCH errors in either state and for Markov state-dependence in the probability of a regime switch (see Hamilton, 1990). Most of the misspecification tests are not significant and suggest that the general regime-switching model captures the salient characteristics of the data. The general regime-switching model nests many competing hypotheses which were discussed in Section 3 (i.e. the fads and mixture normal models). Regardless of the different methods used to measure non-fundamental agricultural land prices, likelihood ratio test statistics suggest that all of the competing models can be rejected in favour of the general regime-switching model.

The bubbles model predicts that the intercept and slope coefficients should be different in the surviving and collapsing regimes. These hypotheses are tested using Wald tests. We can reject the two hypotheses $\beta_{S0}=\beta_{C0}$ and $\beta_{S1}=\beta_{C1}$ in seven out of eight cases at 1% significance level and in all cases at 10% significance level. The estimated slope coefficients, β_{S1} and β_{C1},

of the general regime-switching model are significant in many cases. The slope coefficients for the probability of survival, q, are significant at the 10% level. The bubbles model predicts the following restrictions on the slope coefficients in the general regime-switching model must hold, either $\beta_{S0} \neq \beta_{C0}$, $\beta_{S1} > 0 > \beta_{C1}$, and $\beta_{q1} > 0$ or $\beta_{S0} \neq \beta_{C0}$, $\beta_{S1} < 0 < \beta_{C1}$, and $\beta_{q1} < 0$. The estimated coefficients are consistent with the former set of restrictions when Methods A, B and C is used to proxy for the non-fundamental farmland price. The estimated coefficients are consistent with the latter set of restrictions using Method D. These results offer strong support for the partially collapsing bubbles model.

We can use the model to explore whether it can provide some evidence consistent with Murphy and Nunan's (1993) historical account of the speculative periods. We calculate the conditional probability of a crash in agricultural land prices and plot it over time. A crash is defined as a return that is two-standard deviations, *x*, below the mean return. The probability is calculated as

$$Pr(\Delta p_{t+1} < x) = \left(1 - q\left(p_t^{nf}\right)\right) \bullet \varphi\left(\frac{x - \beta_{C0} - \beta_{C1} p_t^{nf}}{\sigma_C}\right) + q\left(p_t^{nf}\right) \bullet \varphi\left(\frac{x - \beta_{S0} - \beta_{S1} p_t^{nf}}{\sigma_S}\right) \quad (9)$$

where φ is the standard normal cumulative distribution function (see van Norden (1996)). We present these probabilities for the four methods in Figure 3. Given that point estimates are presented, these results must be interpreted with caution. It is evident that the probability of a crash reached a peak in 1979 using Methods A, C and D.

INSERT FIGURE 3 ABOUT HERE

6. Conclusions

Irish agricultural land prices went through a major boom-bust cycle in the late 1970s and early 1980s. In this paper we employed a recently developed regime-switching model to

investigate whether there was a farmland price bubble during this period. The results suggest that the partially collapsing bubbles model provides a reasonable description of the dynamic movements in agricultural land prices over the 1911-96 period. An obvious question is whether the current Irish property and development land price boom will spill over to the agricultural land markets and lead to another boom-bust cycle.

Table 7 summarises national aggregate price movements[14] per acre of agricultural land between 1996 and 1999. After the relatively static level of farmland prices throughout the mid 1980s to early 1990s it is clear that Irish land prices have accelerated between 1996 and 1999 showing a real increase of 55 per cent.

INSERT TABLE 7 ABOUT HERE

Significantly, farm incomes for the same period have fallen by almost 22 per cent in nominal terms. Prices across all the major commodities have declined (some significantly) over the 1996-1999 period. Thus whilst the rapid increase in agricultural land prices throughout the 1970s could be attributed to the general buoyancy in the sector at the time, the same reason cannot be postulated for the more recent increase.

Two major factors present in the 1990s but not in the 1970s were (i) the extra payments resulting from the Common Agricultural Policy (CAP) reform in 1993 and (ii) the rapid growth of the non-agricultural sector of the Irish economy post 1994. The CAP reform has impacted on the intrinsic value of agricultural land in a number of ways. Compensatory packages introduced in the beef and arable sectors are either directly or indirectly tied to land. Arable area aid payments are explicitly made on a per hectare basis while in the beef sector premia payments encourage more extensive production practices. Two "accompanying measures" to the 1993 CAP reform, which also increased demand for land was for forestry

and farmer pensions. Once off grants to forestry were introduced along with annual premiums which are payable only to farmers thereby increasing the shadow value of potential forest land.

The retirement scheme introduced under the CAP reform necessitated the transfer of land by farmers who wished to qualify for the scheme. The person to whom they transferred their land must, on the date of transfer have owned "5ha or more in their own right, which was not the subject of a transfer from the transferor since 30/07/92, or expand the holding by 5ha or 10 per cent of the transferor's holding, whichever is greater". The result of these conditions is to increase the incentives for transferees to buy or rent additional land.

The growth of the non-agricultural Irish economy has also had a stimulatory effect on agricultural land prices. One reason for the increased price of farmland in recent years put forward by the Irish Auctioneers and Valuers Institute (IAVI) is the growth of "hobby" farmers. This refers to the increasing number of people who having enjoyed the benefits of the booming Irish economy are investing in agricultural land. Additionally farmers on the fringe of expanding conurbations are able to sell land at very high values. Many who sell in such circumstances look to reinvest in agricultural land elsewhere. A topic for future research would be to investigate these spillovers from the current housing market boom to developmental and agricultural land markets.

Appendix 1

The Limerick area farmland price and rent data was kindly supplied by Donal Nunan (NUI Cork) and Paul Kelly (Teagasc, Dublin). The data was originally obtained from the auctioneering firm of Fitt and Company of Limerick. Nominal agricultural output and price indices are available from the Central Statistics Office. All nominal series are converted to real by dividing by the consumer price index, which is also available from the Central

Statistics Office. The nominal interest rate is the overdraft rate and is from Honohan and Conroy (1994). The real interest rate was measured as the difference between the nominal rate and the actual consumer price index inflation rate. The data are annual for the period 1911-96.

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Table 1. *Growth rates in Irish agricultural output prices*

Year		Livestock	Livestock Products	Crops	Total
1960-68	Nominal	29.6	19.9	19.5	25.6
	Real	-3.5	-17.7	-18.3	-9.3
1968-77	Nominal	247.7	287.9	229.3	255.4
	Real	28.6	43.5	21.8	31.4

Source: Central Statistics Office
Note: Real Prices Deflated by CPI

Table 2. *Growth rates in Irish and Limerick family farm income*

		Ireland		Limerick	
Year		Total	Per male	Total	Per male
1960-68	Nominal	34.3	45.3	37.7	48.4
	Real	3.4	19.5	8.3	24.1
1968-77	Nominal	336.7	441.9	344.2	421.9
	Real	61.5	100.4	64.3	93.0

Source: Central Statistics Office
Note: Real Prices Deflated by CPI

Table 3. *Growth rates in Irish farm mechanisation*

Year	Tractors	Combine Harvesters	Forage Harvesters	Balers	Milking Parlours
1970-75	35.5	-22.2	18.6	71.1	137.8
1975-80	27.1	8.2	33.7	50.7	3.6
1980-90	3.2	-15.1	10.8	4.2	9.4

Source: Department of Agriculture, Food & Rural Development's' "Statistical Compendium".

Table 4. *Unit root test results*

	Dickey-Fuller	Phillips-Perron	Zivot- Andrews		
			A	B	C
p_t	-1.19	-2.10	-3.96	-2.43	-3.67
r_t	-2.74	-2.63	-3.36	-3.06	-3.81
Δr_t	-7.98*	-7.92*	-8.26*	-7.94*	-8.66*
$\Delta r_t - i_t$	-6.56*	-6.70*	-6.99*	-6.67*	-7.38*
$p_t - r_t$	-1.08	-2.20	-4.61***	-2.68	-4.17
i_t	-4.62*	-4.67*	-4.95*	-4.87*	-5.49*
y_t	-1.92	-1.78	-3.57	-4.03	-3.96
ap_t	-1.31	-1.24	-3.04	-2.65	-2.96

Note: *** denotes significance at the 10% level. ** denotes significance at the 5% level. * denotes significance at the 1% level.

Table 5. *Model selection criterion for the vector autoregression*

Lag length	AIC	SBC	P-value for LR-Test
1	-996.61	-967.88	
2	-994.69	-944.40	0.15
3	-998.72	-926.87	0.23
4	-985.27	-891.89	0.71

Note: The AIC and SBC are the Akaike Information Criterion and Schwartz Bayesian Criterion respectively. The LR-Test is a likelihood ratio test where the restricted model is a VAR with one lag.

Table 6. *Estimated general regime-switching model*

Model of fundamentals	Method A	Method B	Method C	Method D
P-values for the misspecification tests				
AR(1): regime S - $\chi^2(1)$	0.03	0.14	0.32	0.26
AR(1): regime C - $\chi^2(1)$	0.01	0.43	0.02	0.02
ARCH(1): regime S - $\chi^2(1)$	0.39	0.63	0.32	0.16
ARCH(1): regime C - $\chi^2(1)$	0.22	0.43	0.60	0.95
Markov effects - $\chi^2(1)$	0.01	0.18	0.03	0.95
P-values for the likelihood ratio tests				
Bubbles model with constant probability	0.01	0.12	0.00	0.05
Fads model with variable probability	0.01	0.01	0.03	0.01
Fads model with constant probability	0.03	0.03	0.05	0.03
Mixture normal model with variable probability	0.00	0.00	0.00	0.00
Mixture normal model with constant probability	0.01	0.00	0.00	0.00
P-values for the Wald tests				
$\beta_{S0}=\beta_{C0}$	0.01	0.00	0.00	0.00
$\beta_{S1}=\beta_{C1}$	0.00	0.08	0.00	0.00
Parameter estimates				
β_{S0}	-0.012	-0.029	0.030	0.028
	(24.431)	(1.773)	(256.147)	(34.465)
β_{C0}	0.002	0.024	-0.0003	-0.005
	(0.485)	(3.857)	(0.054)	(0.099)
β_{S1}	0.136	0.015	0.024	-0.064
	(95.166)	(0.562)	(73.552)	(5.119)
β_{C1}	-0.023	-0.034	-0.052	0.014
	(2.677)	(4.668)	(4.155)	(6.349)
β_{q0}	3.877	0.990	2.928	2.552
	(3.230)	(1.195)	(5.469)	(4.577)
β_{q1}	5.453	6.626	1.560	-0.504
	(1.331)	(12.195)	(0.460)	(0.204)

Note: Absolute t-statistics are in parenthesis. The absolute t-statistics and Wald tests are based on the inverse of the Hessian. The likelihood-ratio statistics test various parameter restrictions on the switching-regression model. The AR(1) test is a LM test for serial correlation of order one in a particular state. The ARCH(1) test is a LM test for autoregressive conditional heteroscedasticity of order one. Markov effects are a test for Markov-switching effects in a particular state.

Table 7. *Average growth rates in the price per acre of agricultural land between 1996-99*[15]

	January- March	April-June	July-September	Average
Nominal	61.5	66.3	63.4	63.8
Real	52.4	57	54.2	54.4

Source: CSO

Note real prices are deflated by the CPI

Notes

[1] The authors would like to thank Donal Nunan (NUI Cork) and Paul Kelly (Teagasc, Dublin) for the provision of the original data set used by Murphy and Nunan (1993) and the subsequent updating of the series to 1996. While the land price series is available from 1901 the real agricultural price and output series that we use in Section 4 is only available from 1911. Thus the analysis in this paper uses data over the 1911-96 time period.
[2] Since 1996 the Central Statistics Office has started to produce an official land price series.
[3] Then it was called either The Agricultural Institute or An Foras Taluntais.
[4] Nominal farmland prices increased by a whopping 336% between 1975-79 and then fell by 61% between 1979-86.
[5] While this data is primarily sourced from the Central Statistics Office, Attwood and Bateman (1981) present a neat summary.
[6] See Figure 3 p.55 Nunan (1987)
[7] See van Norden (1996) for a thorough description.
[8] The regime-switching model can be estimated by maximum likelihood using Gauss programs kindly supplied by van Norden and Vigfusson (1996).
[9] The results from these Cutler, Poterba and Summers (1991) type regressions using Irish data are available from the authors upon request.
[10] The unit root tests on the first differences of all variables suggest that they are all stationary. These results are available from the authors upon request.
[11] See Falk and Lee (1998) for a thorough description.
[12] The authors are grateful to Falk and Lee (1998) for supplying us with their RATS program.
[13] Traill (1979) uses real farm income. However this series is not available in Ireland for the whole of the 1911-96 period.
[14]The Central Statistics Office (CSO) has recently compiled an annual data series on agricultural land price transactions. Data is obtained from the 'particulars delivered form', which is processed by the Valuation Office. Completed land sales both by auction and by private treaty are included. For more details on the Central Statistics Office series, see the background notes in the Central Statistics Office release on Agricultural Land Sales.
[15] Data at the time of writing was not available for the final quarter of 1999; thus the first three-quarters have been used for presentational purposes.

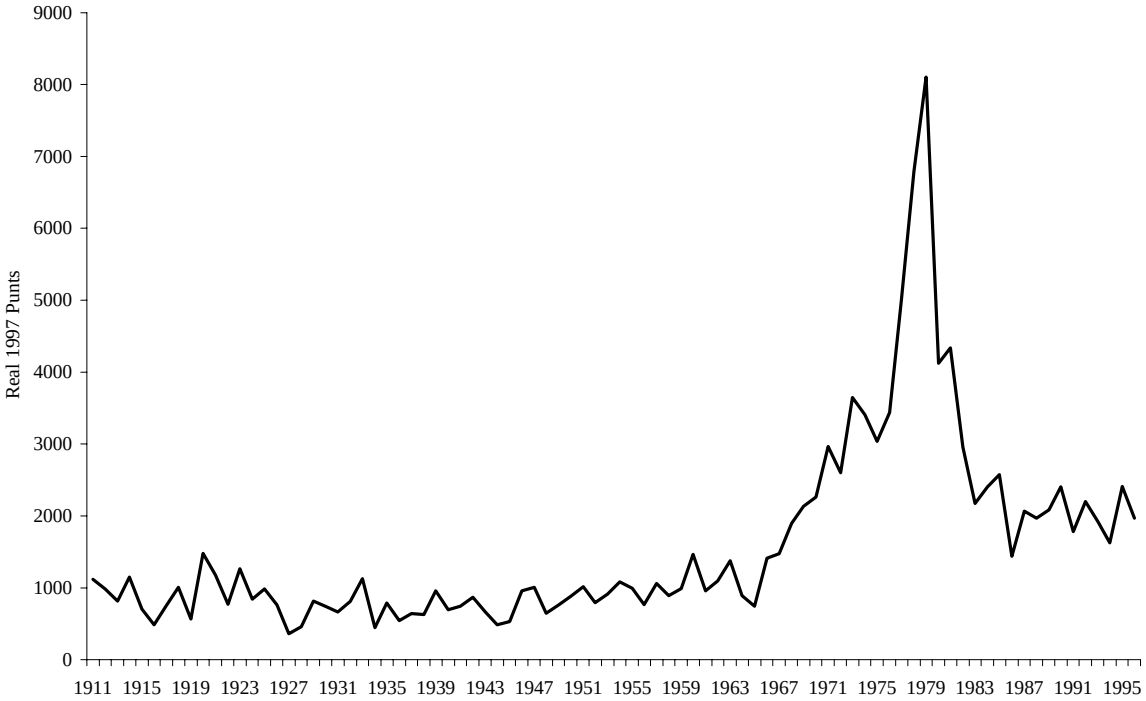

Figure 1. *Real agricultural land prices in the Limerick region of Ireland*

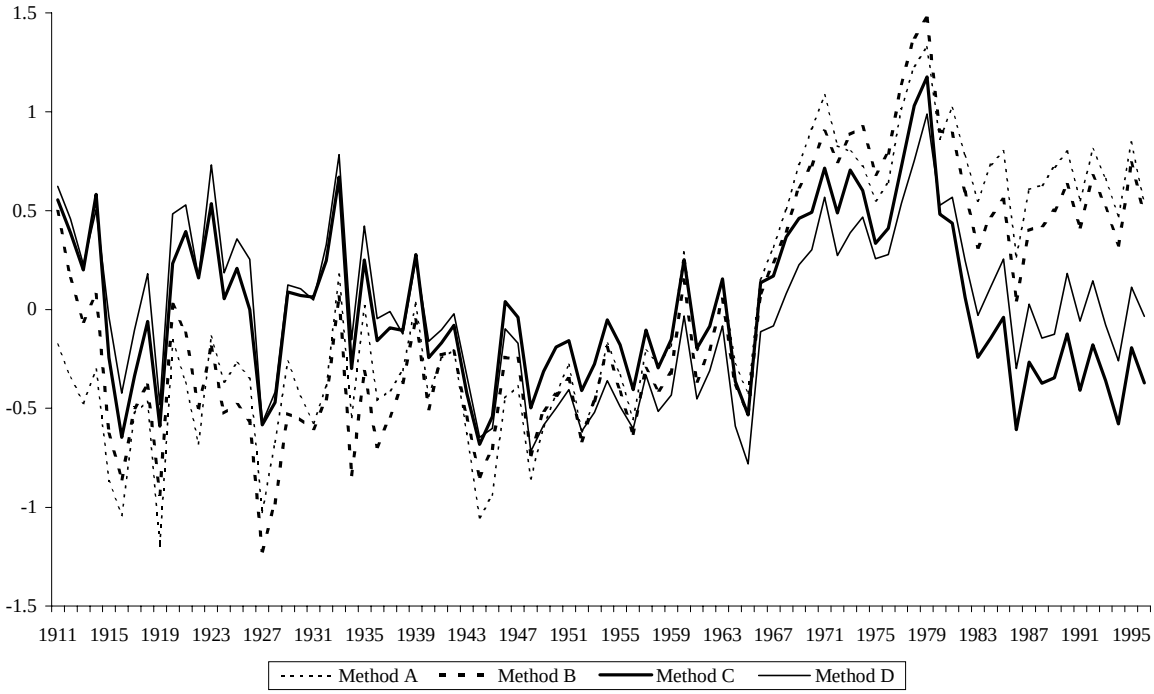

Figure 2. *Estimates of non-fundamental agricultural land prices*

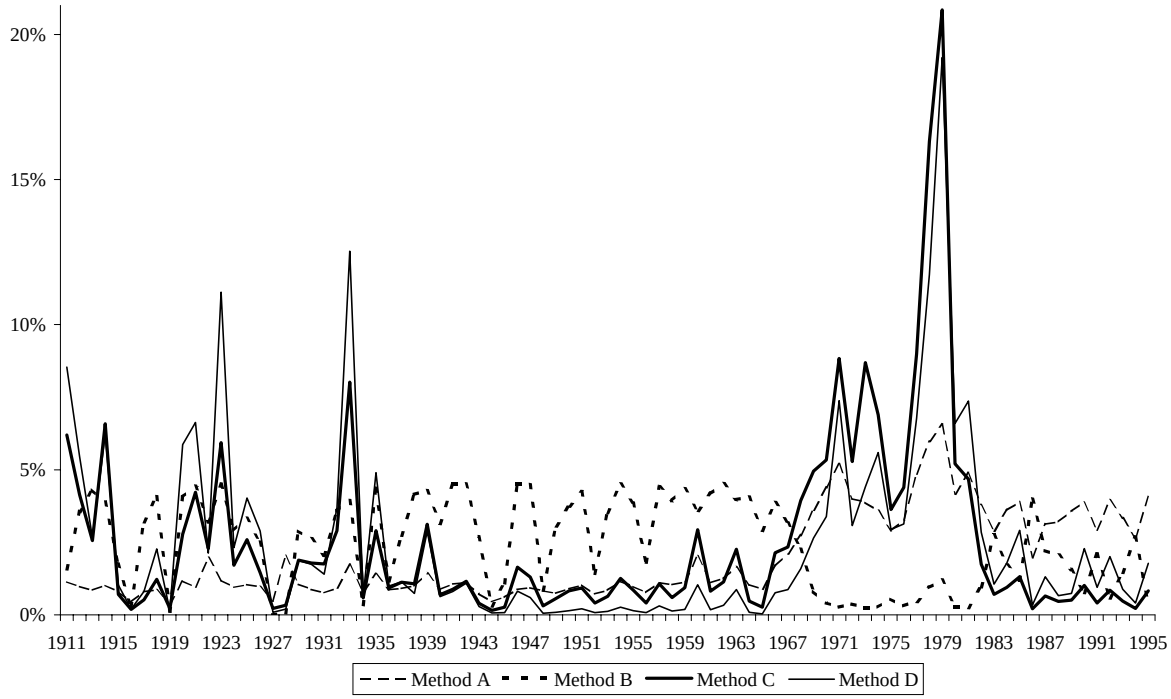

Figure 3. *Estimates of the probability of a crash in agricultural land prices*