

Irish House Prices: Will the Roof Cave In?

By

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Abstract

In the last few years there has been many comments made in the media about the Irish housing market boom. This paper focuses on two of these comments. The first comment is that some economists have suggested that a speculative bubble might be present in Irish house prices. The second comment is that some housing market analysts have asked whether a crash similar to what happened in the British housing market in the late 1980s would occur in Ireland. Many of these analysts suggest that it is highly unlikely that a similar slump would occur in the Irish housing market. Given that bubbles have a habit of bursting one might think that these remarks are contradictory. We reconcile these two comments using regime-switching models of real second hand house prices in Britain and Ireland. The models are estimated and tested to explore whether speculative bubbles, fads or just fundamentals drive house prices. Our main findings suggest that there was a speculative bubble in Britain in the late 1980s and in Ireland in the late 1990s. We estimate that the probability of a crash in Britain reached its highest value of about five percent in the last few quarters of 1989. We also estimate the probability of a crash in the Irish housing market to have increased to around two percent by the end of 1998.

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I INTRODUCTION

The possibility of house price crash in Ireland in the late 1990s similar to that which occurred in the Britain in the late 1980s is an obvious concern to homeowners, the building industry, credit institutions and the government. An article in *The Sunday Business Post*¹ argued that it is highly unlikely that a similar slump would occur in the Irish housing market. However, the Central Bank has suggested that a property bubble exists and this could damage the current economic boom. In addition a report by Bacon, Murphy and MacCabe (1998) stated that “there are risks of a ‘perverse cycle’ emerging in which increasing prices attract more speculative investment demand, in the expectation of yet further price increases”. If bubbles have a habit of bursting it would appear that some of these remarks are contradictory. To our knowledge these comments are just conjecture and not based on any rigorous statistical analysis of the data. This paper attempts to reconcile these two comments. We first explore whether there is a speculative bubble in Irish house prices? Secondly, we ask if there is evidence of a speculative bubble what has been happening to the probability of a crash?

Many of the recent trends in the housing market in Britain and Ireland have been discussed in detail in Muellbauer and Murphy (1997) and Bacon, Murphy and MacCabe (1998) respectively. We report trends in real second-hand house prices in Figure 1 and real house price inflation in Figure 2. The house price data are indices based on average prices of second-hand houses reported by lending agencies over the period 1979:1 to 1998:4 (see Appendix A for details on data sources). In Britain, real house prices increased from the mid-1980s reaching a peak by the second quarter of 1989. Since the third quarter of 1989 real house prices fell dramatically and only recently have started to recover. In Ireland, real house prices fell slightly during the mid-1980s but remained fairly stable up to the first quarter in 1996. Since 1996 real Irish house prices have increased at rates of over ten percent per annum. These annual

¹ Auctioneer Tim McDonald's article "Will British boom-and-bust housing cycle happen here?" on February 1st 1998.

percentage increases in 1998 were much greater than those that occurred in Britain in the late 1980s.

INSERT FIGURE 1 AND FIGURE 2 ABOUT HERE

One has to go beyond these simple trends to ascertain whether the recent increases are driven solely by economic fundamentals. Any deviation of an actual house price away from the fundamental value could be simply thought of as a non-fundamental price. In this paper we investigate the dynamic properties of the latter. If the non-fundamental price behaves in a random fashion then on average house prices reflect fundamental values. However investors, house-movers and builders can speculate and react to factors unrelated to fundamentals (see for example Levin and Wright (1997)). Non-fundamental prices are said to follow a fad if we observe house prices that are temporarily above (or below) fundamental values for long periods of time but are eventually mean-reverting. Alternatively, the anticipation of rising prices induces more market participants in the pursuit of short-term capital gains. Movements in house 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.

There have been many international studies on speculative behaviour in the housing market (see for example, Case and Shiller (1990), Meese and Wallace (1990), and Abraham and Hendershott (1995) for USA, Ito and Hirono (1993) and Ito and Iwaisako (1995) for Japan, Hort (1997) for Sweden, Eitrheim (1995) for Norway). Many of these studies found evidence of speculative behaviour. There is some evidence which suggests that speculation is an important determinant of house prices in Britain (see Hendry (1984), Muellbauer and Murphy (1997), Hall, Psaradakis and Sola (1997), and Levin and Wright (1997)). Most of the research in Ireland has focused on bubbles in land prices (see Browne and Fagan (1992)) or on house price fundamentals (see Nolan (1980), Kenneally and McCarthy (1982), Thom (1983), Irvine (1984),

Kenny (1998), Bacon, Murphy and MacCabe (1998)). Roche (1999) has investigated the possibility of a speculative bubble in Dublin house prices.

In this paper we decompose house prices in Britain and Ireland into their fundamental and non-fundamental components. We use a regime-switching model developed by van Norden (1996), van Norden and Vigfusson (1996a, 1996b) and Schaller and van Norden (1997) to test whether house prices in Britain and Ireland are driven by speculative bubbles, fads or just fundamentals. Our main findings suggest that there was a speculative bubble in Britain in the late 1980s and in Ireland in the late 1990s. We estimate that the probability of a crash in Britain reached its highest value of about five percent in the last few quarters of 1989. We also estimate the probability of a crash in the Irish housing market to have increased to around two percent by the end of 1998.

The remainder of the paper is as follows. In Section II we discuss theoretical regime-switching models of speculative behaviour and the econometric issues involved. In Section III we estimate various models of fundamental house prices. The results from estimating regime-switching models of real house prices are presented in Section IV. The final section offers conclusions.

II REGIME-SWITCHING MODELS

A house price, P_t , can be decomposed into two components. One part is driven by market fundamentals, which we call the fundamental price, P_t^f , and the other part is if prices deviate away from fundamentals, which we call the non-fundamental price P_t^{nf} ,

$$P_t = P_t^f + P_t^{nf}. \quad (1)$$

We examine three types of behaviour of non-fundamental prices. If house prices reflect fundamental values then the non-fundamental price behaves in a random fashion (i.e. an iid random variable). In this case the current non-fundamental price will not be useful for forecasting next periods returns from investing in housing. There are two commonly used

models of non-fundamental prices which allow for non iid behaviour, namely, the fads model proposed by Summers (1986) and the stochastic bubbles proposed by Blanchard and Watson (1982).

In the fads model the non-fundamental price is assumed to persist but not to grow forever. In this case house prices will always revert back to fundamental values. In the stochastic bubbles model Blanchard and Watson (1982) assume 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. They also assume that the non-fundamental price (or bubble) may either survive or collapse with a constant probability, q , and that the expected value of the bubble in a collapse is zero. In other words if the bubble is positive and it collapses the actual price falls by the value of the bubble.

In a series of articles van Norden (1996), van Norden and Vigfusson (1996a), and Schaller and van Norden (1997) argue that the assumption of a constant probability of collapse is too restrictive and assume “that the probability of the bubble’s continued growth falls as the bubble grows”. They also argue that if the bubble collapses the government or financial institutions intervene to stop a complete collapse and so assume that the bubble is expected to partially collapse in state C. See Appendix B for an algebraic derivation of their model. Their general regime-switching regression model that encompasses all three types of behaviour of non-fundamental prices is given by

$$R_{t+1} | S = \beta_{S0} + \beta_{S1} P_t^{nf} + \eta_{S,t+1}, \quad \eta_{S,t} \sim \text{niid}(0, \sigma_S^2), \quad (2)$$

$$R_{t+1} | C = \beta_{C0} + \beta_{C1} P_t^{nf} + \eta_{C,t+1}, \quad \eta_{C,t} \sim \text{niid}(0, \sigma_C^2), \quad (3)$$

and

$$\text{Prob}(\text{State}_{t+1} = S) = q(P_t^{nf}) = \Phi(\beta_{q0} + \beta_{q1} (P_t^{nf})^2) \quad (4)$$

R_{t+1} is the returns (or excess return over twenty-year government bonds) from investing in housing. The probability of the bubble surviving, q , is bounded between 0 and 1 using the logit

function. It is common to find that errors generating excess returns are heteroscedastic.

Assuming heteroscedastic errors of the following form

$$\begin{aligned}\eta_{s,t} &\sim \text{niid}(0, \sigma_s^2) \quad \text{with a prob. of } q, \\ \eta_{c,t} &\sim \text{niid}(0, \sigma_c^2) \quad \text{with a prob. of } 1 - q,\end{aligned}\tag{5}$$

where $\sigma_c > \sigma_s$ permits equations (2)-(4) to nest all three types of non-fundamental price behaviour as special cases.

If house prices are only driven by fundamentals the non-fundamental price will have no explanatory power for future returns. Thus the following restrictions on the general regime-switching model must hold $\beta_{S1} = \beta_{C1} = \beta_{q1} = 0$. In this special case the errors generating R_{t+1} are assumed to be from a mixture of normal distributions. We call this the mixture normal model. The fads model imposes the following restrictions on equations (2)-(4): $\beta_{S0} = \beta_{C0} = \beta_0$, $\beta_{S1} = \beta_{C1} = \beta_1 < 0$, and $\beta_{q1} = 0$. The regime-switching regressions only allow the model to be identified up to a renaming of parameters (i.e. swap the names of the regimes). Therefore the bubbles model imposes the following restrictions on equations (2)-(4): $\beta_{S0} \neq \beta_{C0}$, $\beta_{S1} > 0 > \beta_{C1}$, and $\beta_{q1} > 0$ **or** $\beta_{S0} \neq \beta_{C0}$, $\beta_{S1} < 0 < \beta_{C1}$, and $\beta_{q1} < 0$. Note the bubbles model nests the fads and mixture normal models as special cases. All these restrictions can be tested using likelihood ratio tests. Since we have assumed that the errors generating returns follow normal i.i.d. distributions the loglikelihood function for the general regime-switching model is given by

$$\text{LLF} = \sum_{t=1}^T \ln \left[\begin{aligned} &\left(1 - \frac{1}{1 + e^{(\beta_{q0} + \beta_{q1} (P_t^{\text{nf}})^2)}} \right) \cdot \frac{\varphi\left(\frac{R_{t+1} - \beta_{C0} - \beta_{C1} P_t^{\text{nf}}}{\sigma_c}\right)}{\sigma_c} \\ &+ \left(\frac{1}{1 + e^{(\beta_{q0} + \beta_{q1} (P_t^{\text{nf}})^2)}} \right) \cdot \frac{\varphi\left(\frac{R_{t+1} - \beta_{S0} - \beta_{S1} P_t^{\text{nf}}}{\sigma_s}\right)}{\sigma_s} \end{aligned} \right], \tag{6}$$

where φ is the standard normal probability density function.

Monte Carlo evidence produced by van Norden and Vigfusson (1996a) has shown that the regime-switching tests for bubbles have better finite sample properties than the unit root and cointegration tests for bubbles proposed by Hamilton and Whitman (1985) and Diba and Grossman (1988)². In another Monte Carlo study Evans (1991) has shown that the stationarity tests over reject the presence of bubbles even when a bubble exists by construction. However as Flood and Hodrick (1990) point out, evidence of behaviour predicted by a speculative bubble is not definitive proof that a bubble exists. Regime switching in fundamentals will be observationally equivalent to a regime-switching model motivated by bubbles. Regardless of how one interprets evidence of regime-switching, conclusions should be of interest for at least four reasons. Results consistent with bubbles violates some definitions of market efficiency; suggests that models of regime-switching in fundamentals may have to be addressed; contributes to work on univariate properties of asset prices; and adds to the literature on predictable asset returns.

III MODELS OF FUNDAMENTAL HOUSE PRICES

For most assets there is no unique model of the market fundamentals. In general a proxy is used to measure the fundamental price and thus the non-fundamental price (or bubble). Such a proxy is likely to be measured with error. However misspecifying either the level or the scale of the bubble will have no effect on the regime-switching tests, as the coefficient restrictions and likelihood ratio tests are invariant to linear transformations of the bubble. We estimate four possible measures for house price fundamentals and thus the non-fundamental price. In each case the residual is our estimate of the non-fundamental price.

The first two measures are based on a demand and supply model for housing (see for example Poterba (1984)). This type of model has been used in many studies of the housing market (see for example Hendry (1984), Abraham and Hendershott (1995), Muellbauer and

² Many of the studies mentioned in the introduction have used stationarity tests.

Murphy (1997) and Bacon, Murphy and MacCabe (1998)). Given that housing supply is relatively inelastic we use an inverted demand curve to proxy the fundamental house price. Key demand factors that affect real house prices are real permanent income per capita, expected real mortgage rates and demographic variables. See Appendix A for details of data sources. Quarterly data on permanent income is not available. Therefore we choose two proxies. The first proxy is to use a four-quarter moving average of the volume of retail sales. The second proxy is to use a four-quarter moving average of real disposable income per capita.³ We label these two measures for calculating the fundamental house prices Method's A and B respectively. We also use a four-quarter moving average of nominal mortgage rates less actual house price appreciation for expected real mortgage rates. Demographic variables can either be the total population or the population aged between 25-44 years old.

The third method used to calculate the fundamental price is based on a standard asset-pricing model. The price of an asset is equal to the present discounted value of future dividends. Assuming that dividends can be represented by a time series ARIMA model, it can be shown that the price of an asset is related to the current dividend. Meese and Wallace (1990) suggest that the rental on housing can be used instead of a dividend. Quarterly data on Irish house market rents is not readily available. We assume that the user cost times the real house price can proxy for the real rental price (see for example, Dougherty and van Order (1982)). We call this method for calculating the fundamental price Method C.

The final proxy for fundamental price is atheoretical. Real second-hand house prices are initially fitted to an ARMA(8,4) time series representation. Various information criteria, residual autocorrelation Q-tests and standard t-tests on coefficients are used to produce a parsimonious model. We call this method for calculating the fundamental price Method D.

³ Irish data on real disposable income per capita is available annually and is interpolated.

ARMA(5,4) and ARMA(4,1) models produced the best fit for real second-hand house prices in Britain and Ireland respectively.

Loglinear representations are estimated and the regression results for fundamental house prices using Method's A, B and C are presented in Table 1. The income and real interest rate variables all significant at conventional levels have the correct sign. Demographic variables were initially included in the regression equation tend to be either insignificant or have the wrong sign. Since population looks like a linear trend it tends to pick up the fall in real house prices in the 1990s in Britain and in the mid 1980s in Ireland.

INSERT TABLE 1 ABOUT HERE

In the last two columns of Table 1 report the results from a static regression equation relating real house price to real rents. For Ireland this equation is estimated using the level of the series rather than the log-level. This is because some of the rents are negative due to house price appreciation. While one would expect a positive relationship between actual rental rates and house prices, the estimated coefficient for Ireland is negative and significant. This reflects the dominance of capital gains in our definition of real rental rates. We tested all regressions for parameter stability using tests developed by Hansen (1991).⁴ The results of the tests suggest that the coefficients on expected real income using Method's A and B and on rent using Method C were not stable over the time period. This may suggest that regime switching in the process generating fundamental house prices occurred over this time period.

In order to estimate the switching regression model (2)-(4) a series for excess returns from investing in housing, R_t , needs to be constructed. We follow Cutler, Poterba and Summers (1991) and use

$$R_t = \log\left(\frac{P_t}{P_{t-1}}\right) - \log(1 + i_{bt}). \quad (8)$$

⁴ The results are available from the author upon request.

IV RESULTS

We estimate the regime-switching model (2)-(4) using data on excess returns and estimates of non-fundamental house prices. The results for British house prices are presented in Table 2. The sample period is 1976:2-1998:4. We report coefficient estimates and their associated absolute t-statistics, probability values of the likelihood ratio, Wald and misspecification test statistics. The switching-regression model nests many other models. We use likelihood ratio statistics to test the bubbles model against five alternative nested regime-switching models, namely, a bubbles model with constant probability of collapse, a fads model with variable probability of collapse, a fads model with constant probability of collapse, a mixture normal model with variable probability of collapse, and a mixture model with constant probability of collapse. The Wald statistics are used to test the parameter restrictions on the general regime-switching model implied by the bubbles model. The misspecification tests 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) for a discussion on the properties of these tests).

INSERT TABLE 2 ABOUT HERE

In general the results are very supportive of the bubbles model. The results indicate that the general regime-switching model cannot be rejected in favour of any of the five alternative models. The following restrictions on (2)-(4), $\beta_{S0} \neq \beta_{C0}$, $\beta_{S1} > 0 > \beta_{C1}$, and $\beta_{q1} = 0$ are fairly consistent across whichever method is chosen to estimate the fundamental price. Most of the coefficients in the collapsing state are highly significant. Thus the bubble measure has significant influence on the excess return. We can also reject $\beta_{S0} = \beta_{C0}$ and $\beta_{S1} = \beta_{C1}$ in six of the eight cases using conventional significance levels. The parameters that affect the classification probabilities appear to be imprecisely estimated. This result is also mirrored in the fact that the misspecification tests for Markov effects are significant.

INSERT FIGURE 3A AND FIGURE 3B ABOUT HERE

The results suggest that the bubbles model captures salient characteristics of the data but the method for classifying regimes needs to be researched further. An answer to our first question asked in the introduction to the paper is that there is some evidence of speculative bubble behaviour in British house prices. We can examine the behaviour of the general regime-switching model more closely by considering the results using non-fundamental prices estimated using Method A over time. These figures are based on point estimates so caution should be exercised in their interpretation. In Figure 3(a) we present an estimate of the bubble (measured on the left-hand-side) and the probability of a fall in excess returns, $1-q$, (measured on the right-hand-side). We estimate that the bubble in British house prices grew in the late 1980s. The probability of a fall in the bubble also reached a peak at this time. One of the media comments about the rise in house prices mentioned in the introduction is the possibility of a crash. We will define a crash as a two-standard deviation fall below the mean in excess returns. This can be calculated using a weighted average (using q) of probabilities from the normal density function. In Figure 3(b) we present an estimate of the bubble (measured on the left-hand-side) and the probability of a crash in real house prices (measured on the right-hand-side). It is evident that the probability of a crash reached a peak of five percent in 1989.

INSERT TABLE 3 ABOUT HERE

The results for Irish house prices are presented in Table 3. The sample period is 1979:1-1998:4. In general the results are also very supportive of the bubbles model. The results indicate that for Methods A, B and C the general regime-switching model cannot be rejected in favour of any of the five alternative models. It would appear that the estimate of the non-fundamental price using an ARMA(5,4) fits each regime-switching model equally well. The following bubbles model restrictions on the general regime switching model (2)-(4),

$\beta_{S0} \neq \beta_{C0}$, $\beta_{S1} > 0 > \beta_{C1}$, and $\beta_{q1} = 0$ are fairly consistent across whichever method is chosen to estimate the fundamental price. Most of the coefficients in both states are highly significant although the slope coefficient in a surviving state is negative using Method's A and B.

We can also reject $\beta_{S0} = \beta_{C0}$ and $\beta_{S1} = \beta_{C1}$ in seven of the eight cases using conventional significance levels. The parameters that affect the classification probabilities appear to be more precisely estimated using Irish data. As with British data the results suggest that the bubbles model fit the data reasonably well. An answer to our first question asked in the introduction to the paper is that there is also some evidence that a speculative bubble exists in Irish house prices.

INSERT FIGURE 4A AND FIGURE 4B ABOUT HERE

In Figure 4(a) we present an estimate of the bubble (measured on the left-hand-side) and the probability of a fall in excess returns (measured on the right-hand-side). In Figure 4(b) we present an estimate of the bubble and the probability of a crash in excess returns. We estimate that Irish fundamental house prices fluctuated within five percent of actual house prices up to 1996. Since 1997 the estimated bubble has grown but not as rapid as what happened in Britain in the late 1980s. Between 1979-97 the probability of a crash (or even a fall) in real house prices has remained more or less constant. However the probability of a crash in real second-hand house prices has recently increased to around two percent. It would appear the current Irish market fundamentals are much stronger than what occurred in Britain in the late 1980s.

V CONCLUSIONS

There has been much comment and debate in the media about the current boom in Irish house prices. Some commentators have suggested that there may be a speculative bubble in the housing market. Others have suggested that a crash similar to Britain in the late 1980s would not occur here. We employ recently developed testing procedures for speculative bubbles based on regime-switching models to evaluate these remarks. Our

findings indicate that there is some evidence of speculative bubble in Irish house prices but the probability of a crash is much lower than that estimated for Britain in the late 1980s. The evidence is strongest when we use methods to calculate fundamental house prices similar to those used in the first Bacon report.

Economic forecasts for Ireland are for the continuation of the current economic boom and for possibly lower interest rates. This will have a tendency to increase the demand for housing well into the next millennium. If the increased demand is not matched by supply, house prices will inevitably rise even further. If a bubble already exists in the market the problem will be exacerbated and the probability of a crash will most likely increase. Recently announced government policies of land rezoning to increase supply should be implemented as soon as possible. Future research will focus on the factors that may cause speculative bubbles in the housing market and on the possibility of regime-switching in fundamentals.

APPENDIX A: DATA SOURCES

All British data is available from Datastream. The real house price series is the Nationwide Anglia index of modern second hand house prices deflated by the consumer price index. Retail sales and real disposable income are seasonally adjusted. The mortgage rate series is the building societies interest rate on new mortgages to owners. The long-term interest rate gross redemption yield on twenty-year gilts. The rental series is the rent component in the consumer price index. British population data is available annually and is interpolated to produce a quarterly series. Irish house price data are provided in the Annual and Quarterly Housing Bulletins published by the Department of the Environment and Local Government. The data are based on returns from lending institutions and are the average prices of second-hand houses in Ireland. Real disposable income and population data are available annually from the Economic and Social Research Institute's macroeconomic databank. The long-term interest rate

is the yield on twenty-year government bonds is available from Central Bank bulletins. Data on retail sales and the consumer price index is available from Central Statistics Office Economic Series and Statistical Bulletins.

The real rental price can be defined as

$$rh = [(\alpha i_b + (1 - \alpha) i_m)(1 - \tau) + \delta - \dot{p}^e] p, \quad (7)$$

where α is the downpayment as a fraction of the purchase price, i_b is the nominal rate of interest long term bonds, i_m is the nominal rate of interest on mortgages, τ is the marginal tax rate applicable to mortgages, δ is a depreciation rate and \dot{p}^e is the expected growth rate in housing prices. The downpayment as a fraction of the purchase price is calculated as the average price less the average amount borrowed divided by the average price and can be calculated using the Annual and Quarterly Housing Bulletins published by the Department of the Environment and Local Government. The marginal tax rate applicable to mortgages is chosen as the top marginal rate and the data is available from the revenue commissioners. The depreciation rate on houses is chosen to be 1% per quarter. We use the actual quarterly capital gains as a proxy for the expected growth rate in housing prices.

APPENDIX B: A REGIME SWITCHING MODEL

In this appendix we outline the arguments behind the general regime-switching model (see van Norden (1996) and references therein for a complete description). In the fads model the fundamental price is assumed to be a non-stationary component.

$$P_t^f = P_{t-1}^f + e_t, \quad e_t \sim \text{iid}(0, \sigma_e^2). \quad (B1)$$

The non-fundamental price is assumed to persist but not to grow forever. Thus

$$P_t^{\text{nf}} = \rho P_{t-1}^{\text{nf}} + v_t, \quad 1 > \rho > 0, \quad v_t \sim \text{iid}(0, \sigma_v^2). \quad (B2)$$

One difficulty is that in most cases there is no unique model of the market fundamentals. In general a proxy is used to measure the fundamental price. Such a proxy is likely to be measured

with error. Summers (1986) and Cutler, Poterba and Summers (1991) use an error-in-variables approach. They assume that

$$P_t^p = P_t^f + u_t, \quad u_t \sim \text{iid}(0, \sigma_u^2), \quad (\text{B3})$$

where P_t^p is the proxy and u_t is the measurement error. Manipulating (B1) to (B3) gives

$$P_{t+1} - P_t = \beta_1(P_t - P_t^p) + \varepsilon_t, \quad \varepsilon_t \sim \text{iid}(0, \sigma_\varepsilon^2), \quad (\text{B4})$$

which relates the returns to differences between the actual price and the proxy for fundamentals.

Equations (B1) and (B4) imply that this difference is just the non-fundamental price plus a random measurement error. Thus the fads model can be written as

$$R_{t+1} = \beta_0 + \beta_1 P_t^{\text{nf}} + \eta_t. \quad (\text{B5})$$

R_t is the excess return over the yield on a risk free asset.

An alternative model of non-fundamental house price behaviour is that of a partially collapsing speculative bubble variety. Although the fundamental price is a standard solution to asset pricing models, there is also a bubble solution of the form

$$P_t^{\text{nf}} = \alpha E_t(P_{t+1}^{\text{nf}}) \quad 1 > \alpha > 0, \quad (\text{B6})$$

which also satisfies asset-pricing models. van Norden (1996), van Norden and Vigfusson (1996a), and Schaller and van Norden (1997) assume 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. They argue that the probability of the bubble's continued growth, q , falls as the bubble grows.

Thus

$$q = q(P_t^{\text{nf}}), \quad \frac{\partial q(P_t^{\text{nf}})}{\partial |P_t^{\text{nf}}|} < 0. \quad (\text{B7})$$

They also argue that that the bubble would only partially collapse in state C. Thus

$$E_t(P_{t+1}^{\text{nf}} | C) = g(P_t^{\text{nf}}) \quad 0 \leq g' \leq 1 \quad g(0) = 0, \quad (\text{B8})$$

where $g(\bullet)$ is a continuous and everywhere differentiable function. The expected size of the collapse is a function of the non-fundamental price. Using (B6)-(B8) the expected value of the non-fundamental price in state S is given by

$$E_t(P_{t+1}^{nf} | S) = \frac{P_t^{nf}}{\alpha q(P_t^{nf})} - \left(\frac{1 - q(P_t^{nf})}{q(P_t^{nf})} \bullet g(P_t^{nf}) \right) \quad (B9)$$

Van Norden (1996) and Schaller and van Norden (1997) show that in state C the expected return on an asset will be a decreasing function of the bubble, and in state S the expected return on an asset will be an increasing function of the bubble. They show that (B8) and (B9) impose the following structure on excess returns

$$E_t(R_{t+1} | C) = g(P_t^{nf}) - \frac{P_t^{nf}}{\alpha}, \quad (B10)$$

and

$$E_t(R_{t+1} | S) = \left(\frac{1 - q(P_t^{nf})}{\alpha q(P_t^{nf})} \bullet (P_t^{nf} - \alpha g(P_t^{nf})) \right) \quad (B11)$$

The model estimated in the paper is based on a first order Taylor series expansion of B(10) and (B11). Finally they assume that the probability of the bubble surviving, q , is bounded between 0 and 1 and use the following Logit function

$$\text{Prob}(\text{State}_{t+1} = S) = q(P_t^{nf}) = \Phi(\beta_{q0} + \beta_{q1} (P_t^{nf})^2) \quad (B12)$$

Assuming that the error term in (B5) is heteroscedastic will allow us to nest the fads model within the general regime-switching model.

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Table 1: *Models of Fundamental Prices*

	<i>Method A</i>		<i>Method B</i>		<i>Method C</i>	
	<i>Ireland</i>	<i>Britain</i>	<i>Ireland</i>	<i>Britain</i>	<i>Ireland</i>	<i>Britain</i>
Intercept	-1.10 (3.46)	1.65 (6.71)	-0.67 (1.13)	0.14 (0.27)	-101.28 (56.89)	2.93 (9.84)
Income	1.24 (18.11)	0.62 (11.53)	0.62 (8.94)	0.58 (7.95)		
Interest rates	-0.02 (7.10)	-0.013 (2.77)	-0.04 (10.66)	-0.016 (2.70)		
Rent					-2.59 (6.68)	0.33 (5.10)
\bar{R}^2	0.93	0.57	0.82	0.39	0.36	0.22

Notes to the table: The data range for Irish second-hand new house prices is 1979:01-1998:03. The data range for British second-hand house prices is 1976:01-1998:03. Method A uses the volume retail sales as a proxy for permanent income. Method B uses real disposable income per capita as a proxy for permanent income. Absolute t-statistics are in parenthesis.

Table 2: Regime Switching Model Regression Results for Britain

<i>Model of fundamentals</i>	<i>Method A</i>	<i>Method B</i>	<i>Method C</i>	<i>Method D</i>
Mean value of the loglikelihood function	2.336	2.301	2.297	2.340
	<i>Parameter estimates</i>			
β_{S0}	0.003 (0.46)	0.003 (0.40)	0.003 (0.58)	-0.003 (16.83)
β_{C0}	-0.018 (5.93)	-0.019 (3.95)	-0.021 (5.60)	-0.009 (3.11)
β_{S1}	0.059 (0.82)	0.049 (0.87)	0.074 (1.97)	0.273 (54.09)
β_{C1}	-0.106 (5.81)	-0.080 (4.42)	-0.065 (4.04)	0.475 (3.24)
β_{q0}	0.135 (0.25)	0.042 (0.05)	-0.071 (0.14)	2.296 (5.15)
β_{q1}	32.016 (1.36)	9.78 (0.62)	3.23 (0.36)	-359.92 (1.54)
	<i>P-values</i>			
<i>Likelihood ratio tests</i>				
Bubbles model with constant probability	0.16	0.00	0.00	0.16
Fads model with variable probability	0.00	0.03	0.02	0.00
Fads model with constant probability	0.00	0.02	0.00	0.00
Mixture normal model with variable probability	0.00	0.01	0.03	0.00
Mixture normal model with constant probability	0.00	0.02	0.03	0.00
<i>Wald tests</i>				
$\beta_{S0}=\beta_{C0}$	0.00	0.00	0.00	0.04
$\beta_{S1}=\beta_{C1}$	0.03	0.04	0.09	0.17
<i>Misspecification tests</i>				
AR(1): regime S - $\chi^2(1)$	0.00	0.00	0.00	0.26
AR(1): regime C - $\chi^2(1)$	0.13	0.03	0.07	0.00
ARCH(1): regime S - $\chi^2(1)$	0.19	0.22	0.40	0.26
ARCH(1): regime C - $\chi^2(1)$	0.72	0.50	0.28	0.83
Markov effects - $\chi^2(1)$	0.00	0.00	0.00	0.00

Notes to the table: 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 3: *Regime Switching Model Regression Results for Ireland*

<i>Model of fundamentals</i>	<i>Method A</i>	<i>Method B</i>	<i>Method C</i>	<i>Method D</i>
<i>Mean value of the loglikelihood function</i>	2.022	1.925	1.969	1.853
	<i>Parameter estimates</i>			
β_{S0}	-0.010 (3.01)	-0.010 (2.66)	0.0002 (0.04)	-0.010 (2.46)
β_{C0}	0.114 (71.07)	0.126 (30.06)	-0.027 (23.03)	0.101 (4.64)
β_{S1}	-0.265 (2.96)	-0.043 (0.71)	0.001 (3.35)	0.059 (0.37)
β_{C1}	-0.648 (27.98)	-0.461 (11.29)	0.003 (16.56)	-0.302 (0.79)
β_{q0}	-3.105 (5.23)	-3.159 (5.11)	-4.23 (1.56)	-3.050 (4.31)
β_{q1}	417.260 (2.44)	151.23 (2.24)	-0.01 (1.11)	536.59 (1.84)
	<i>P-values</i>			
<i>Likelihood ratio tests</i>				
Bubbles model with constant probability	0.00	0.00	0.00	0.20
Fads model with variable probability	0.00	0.00	0.02	0.26
Fads model with constant probability	0.00	0.00	0.04	0.35
Mixture normal model with variable probability	0.00	0.00	0.02	0.73
Mixture normal model with constant probability	0.00	0.02	0.00	0.20
<i>Wald tests</i>				
$\beta_{S0}=\beta_{C0}$	0.00	0.00	0.00	0.00
$\beta_{S1}=\beta_{C1}$	0.00	0.00	0.00	0.38
<i>Misspecification tests</i>				
AR(1): regime S - $\chi^2(1)$	0.41	0.24	0.34	0.28
AR(1): regime C - $\chi^2(1)$	0.08	0.00	0.88	0.00
ARCH(1): regime S - $\chi^2(1)$	0.94	0.41	0.19	0.35
ARCH(1): regime C - $\chi^2(1)$	0.00	0.00	0.80	0.00
Markov effects - $\chi^2(1)$	0.00	0.00	0.37	0.82

Notes to the table: 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.

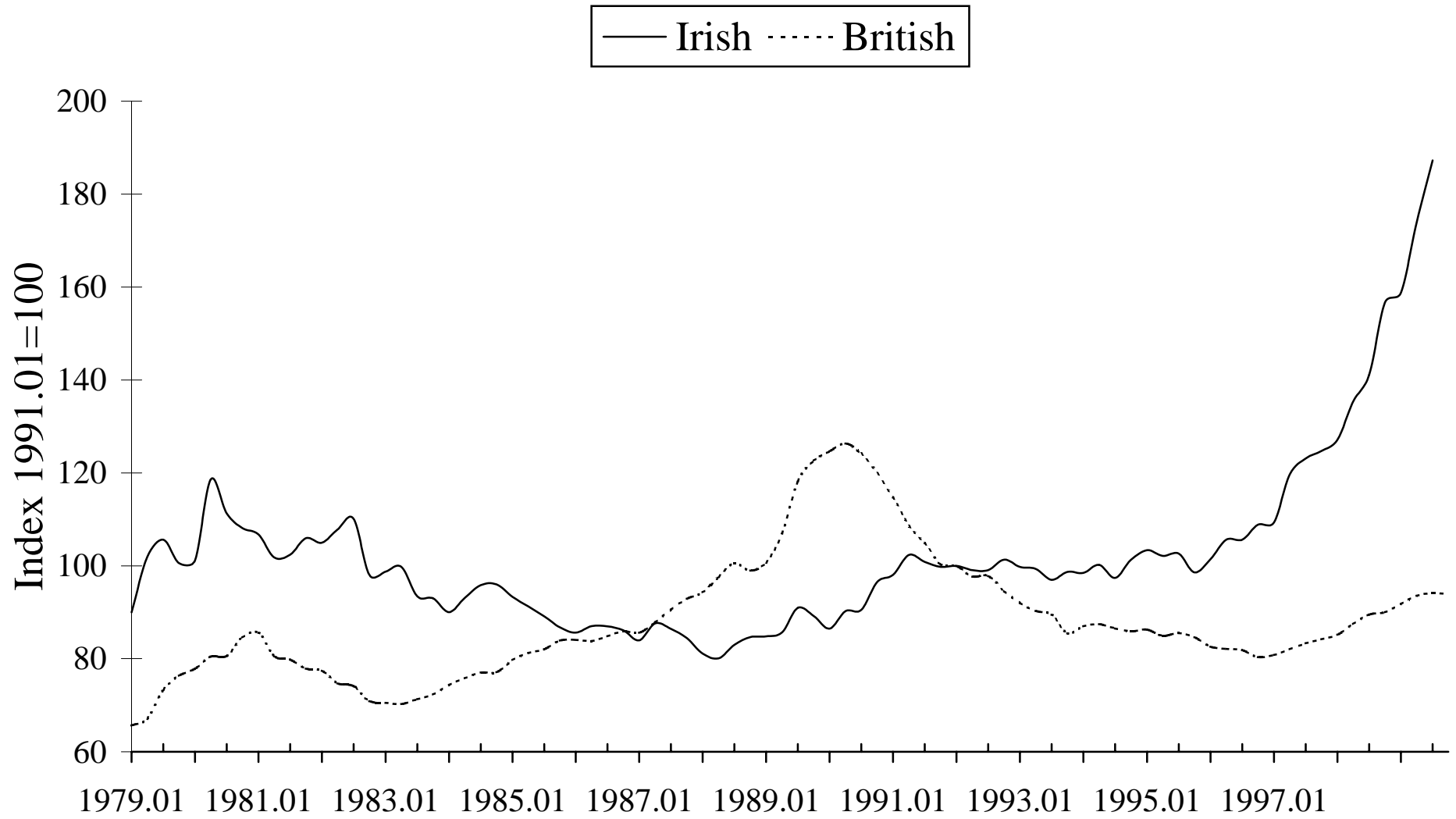


Figure 1: *Real House Prices*

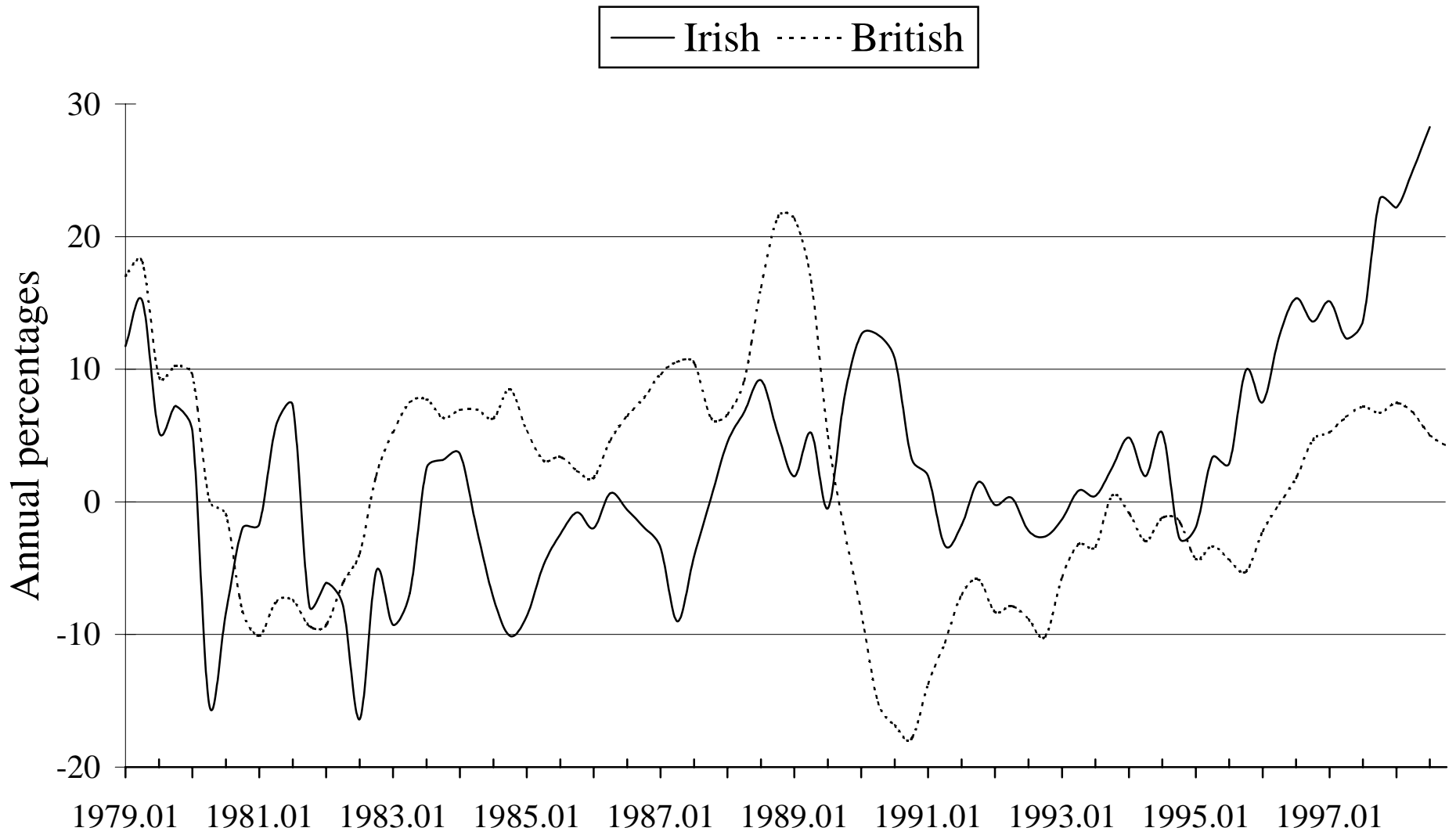


Figure 2: *Real House Price Inflation*

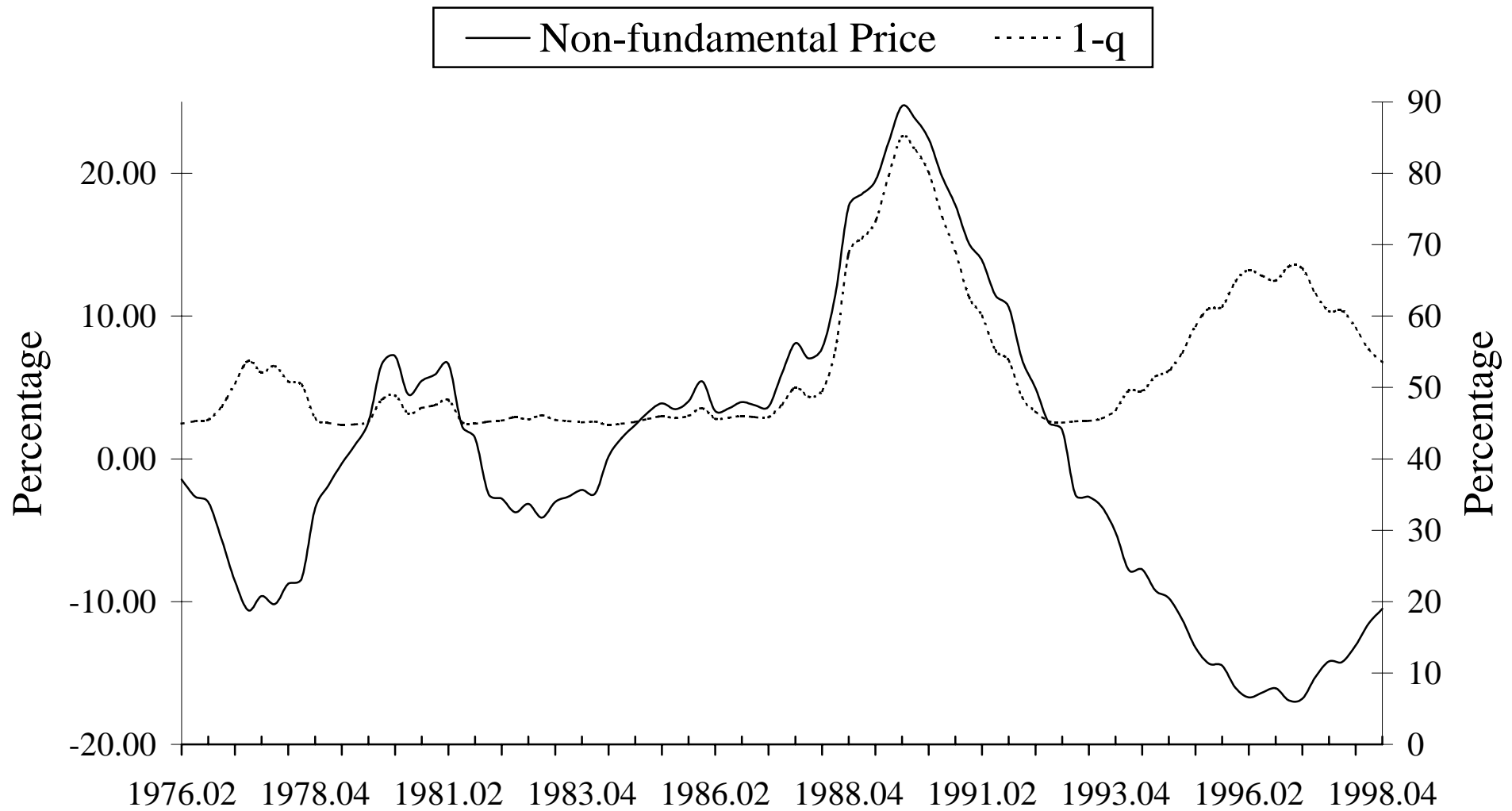


Figure 3a: *Estimate of the British non-fundamental house price and its probability of a fall*

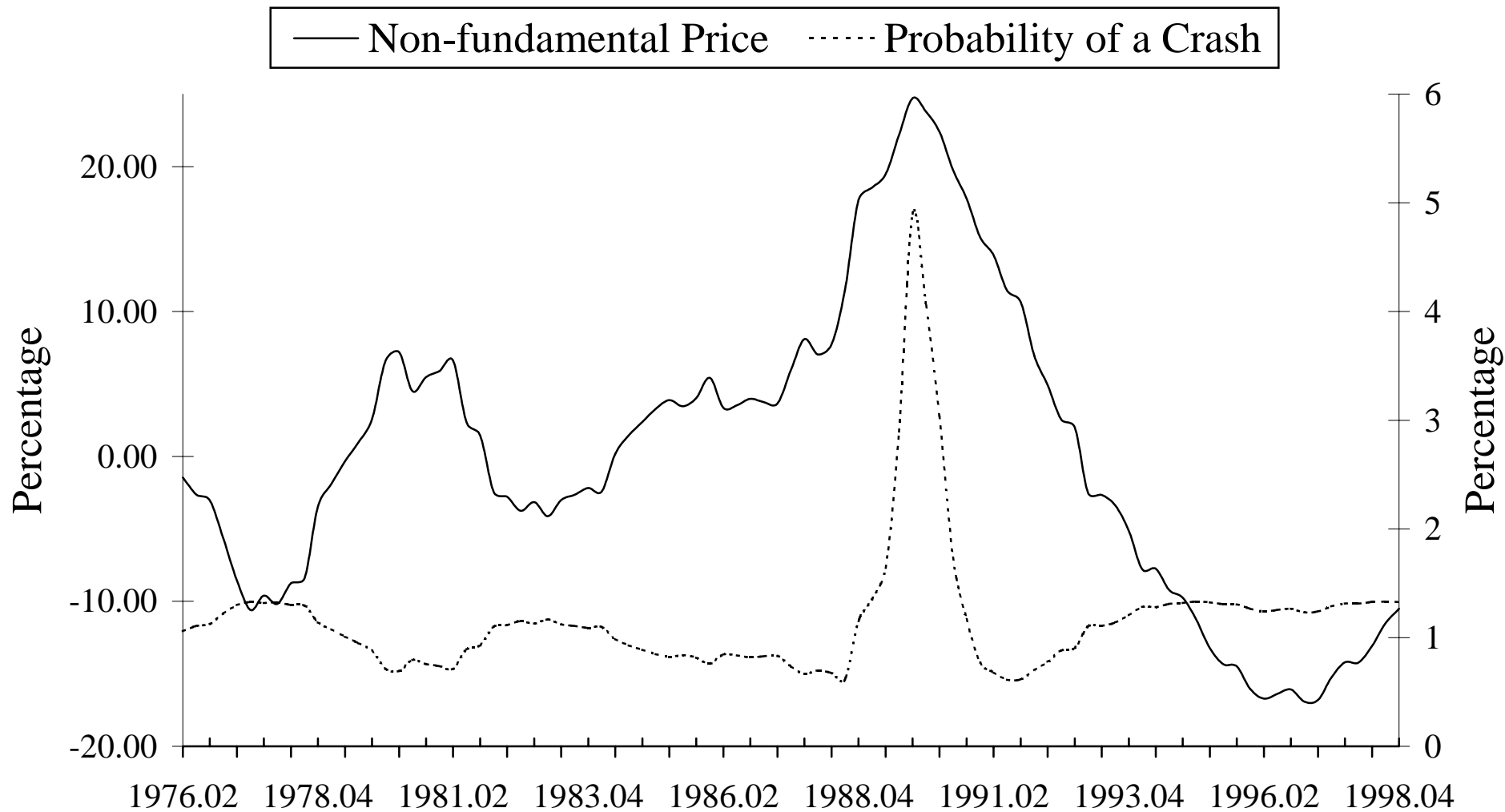


Figure 3b: *Estimate of the British non-fundamental house price and the probability of a crash*

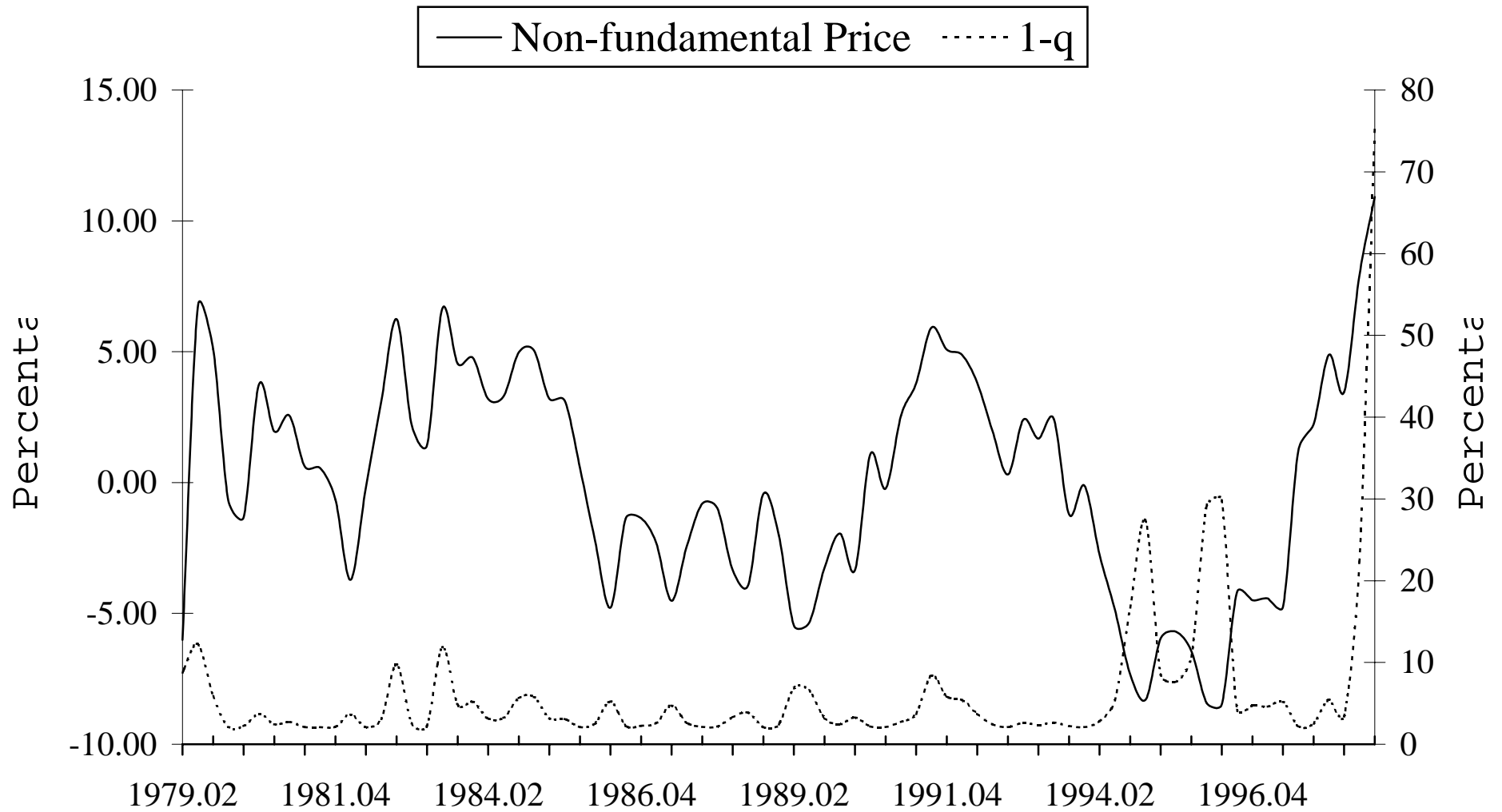


Figure 4a: *Estimate of the Irish non-fundamental house price and its probability of a fall*

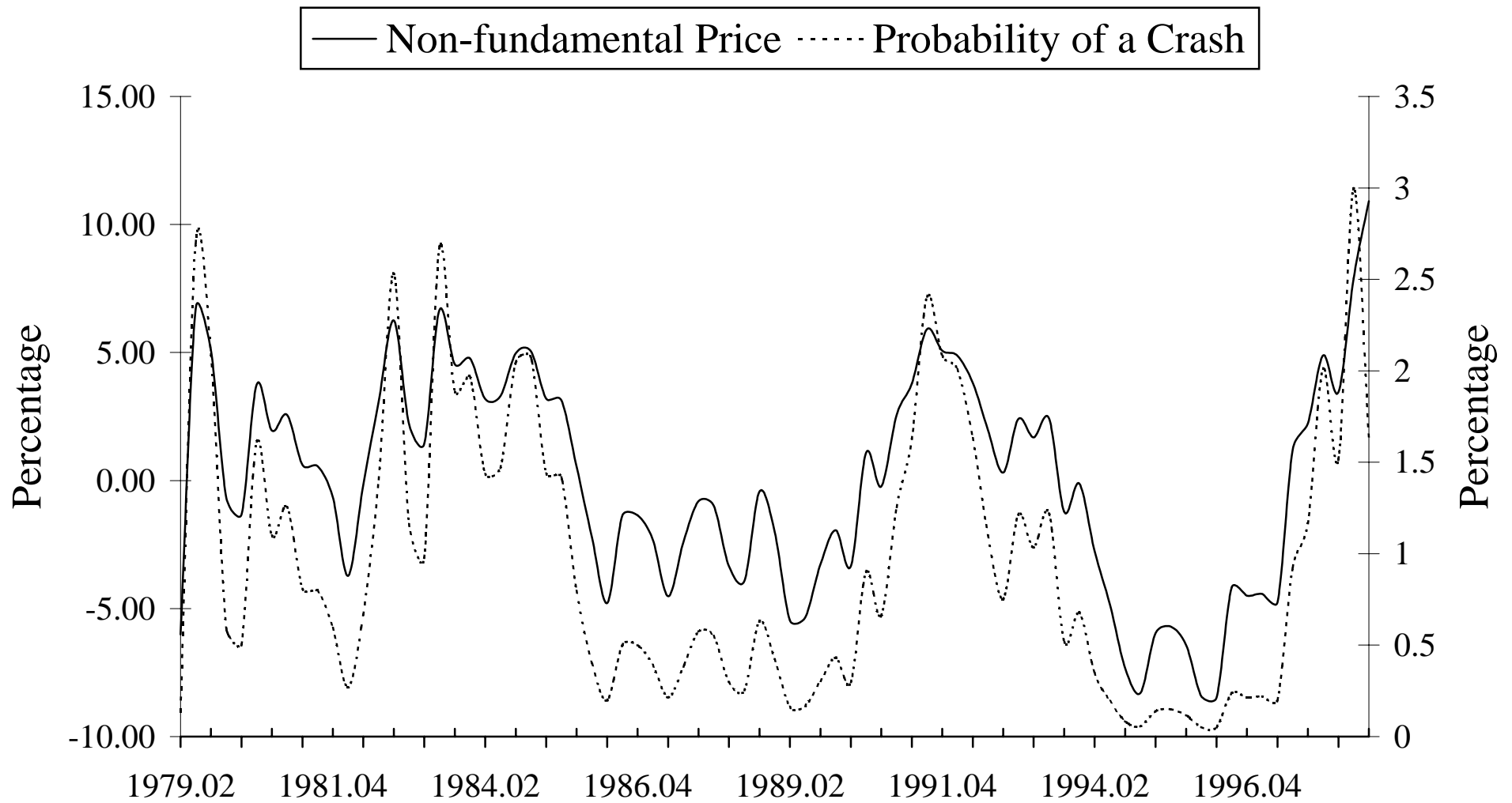


Figure 4b: *Estimate of the Irish non-fundamental house price and the probability of a crash*