

WILL THERE BE A CRASH IN IRISH HOUSE PRICES?

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1. Introduction

The late 1990s was a period of very rapid house price increases in Ireland. The pace of increase was such as to prompt the government to commission three separate consultancy reports on the housing market in an effort to identify a policy response (see Bacon, MacCabe and Murphy (1998), Bacon and MacCabe (1999) and Bacon and MacCabe (2000)). Indeed, the boom in house prices in the late 1990s focused much attention, domestically and internationally, on the housing market. The continued strong growth in Irish house prices at a time when the economy has slowed has promoted some commentators to express some concerns about the outlook for the Irish housing market. From an international perspective two of the more high profile analyses have been from *The Economist* newspaper and the International Monetary Fund.

In May 2003 *The Economist* predicted that Irish house prices were overvalued by 42 per cent would fall by 20 per cent over the next four years. In August 2003, the International Monetary Fund (2003) was more cautious warning that Irish “house prices may be significantly overvalued”. Their results suggest that Irish house prices are “16.5 per cent higher than its long-run equilibrium” value and could be overvalued by “50 per cent!” Domestically, there has also been some concern expressed about the housing market. In June 2003 NCB Stockbrokers (2003) state that “there are some risks of a setback to house prices though probably not a collapse”. In October 2003 the Central Bank of Ireland (2003), in its Autumn *Quarterly Bulletin*, warned that “to the extent that there may be overvaluation present, a continued rise in house prices could be followed by quite a disruptive adjustment as prices revert to their fundamental values”. In contrast, IIB Bank (2003) believe that there is no bubble in the market and that house prices are approximately equal to the long-run equilibrium (or fundamental) value. Most of these comments appear to be conjecture based on a visual examination of trends in house price/income ratios, real mortgage rates and demographics, and not as a result of rigorous statistical analysis. There are some reports such as the article by the International Monetary Fund (2003) in which statistical analysis is presented. However, their econometric model for house price

fundamentals completely omits supply side factors. In this article we show that this overestimates how far actual prices are above fundamentals.

We present statistical evidence suggesting that the pessimistic predictions about the level of Irish house prices are, at best, unwarranted and based on inappropriate models of house price fundamentals, and at worst they are sensationalist. The irony is that if enough Irish people believe the prophecy of falling house prices and try to sell their house, they will flood the market and the prophecy could become self-fulfilling.

Our findings suggest that, at worst house prices are currently overvalued by slightly less than 5 per cent and at best they actually reflect fundamentals. Our results show that while there may have been a bubble in house prices in the late 1990s, events since then have dampened the market and price levels are reverting back to their fundamental values. Our analysis suggest that the recent increase in house prices may not be caused by would be speculators buying houses in the anticipation of further increases in some self-fulfilling prophecy, or what *The Economist* calls a “bubbly housing market” but as a result of strong trends in demand and supply fundamentals.

These results, however, do not imply that there are no problems in the housing market. Since the beginnings of the current housing boom in 1995 many young first time buyers are being gradually priced out of the market. This is in part due to a shift upwards in both the housing supply curve, as land and other building costs have increased, and in the demand for housing curve, as the loan-to-value ratio, disposable income and net immigration have all increased and mortgage rates have fallen. Our results also indicate that trends in land costs are the most important factor explaining the trend in new house prices and it is perhaps here the government should be directing more attention.

The structure of the paper is as follows: Section 2 provides an overview of house price developments and the factors driving housing demand and supply. Section 3 provides a non-technical analysis of models used to explain the fundamental value of Irish houses and tests performed to determine if a bubble in Irish house prices exists or not. Section 4 presents some conclusions from the analysis. The paper also includes an Appendix setting out the technical details of the econometric models underpinning the analysis contained in Section 3.

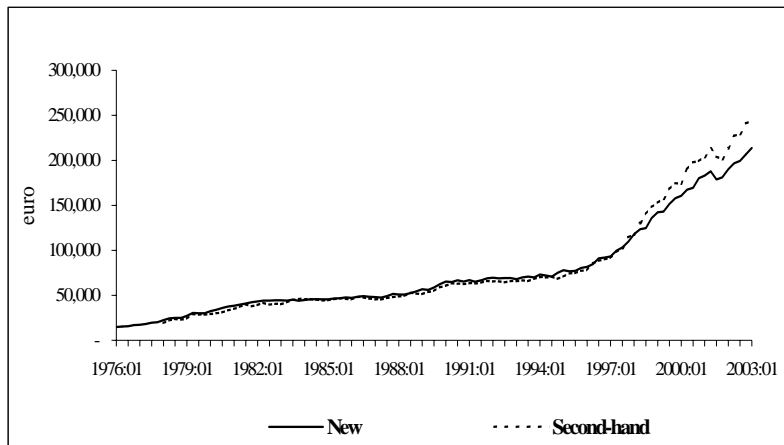
2. A Review of the Facts

Almost every adult on this island is aware that Irish house prices have risen dramatically since 1995, see Figure 1. *The Economist* newspaper would have us think that there is a bubble in the market and that house prices are overvalued by over 40 per cent. What does one mean by the expression “a bubble in house prices” and how does one value a house? The New Palgrave: a *Dictionary of Economics*¹ defines a bubble as “a sharp rise in the price of an asset or a range of

¹ Eatwell, Milgate and Newman (1998).

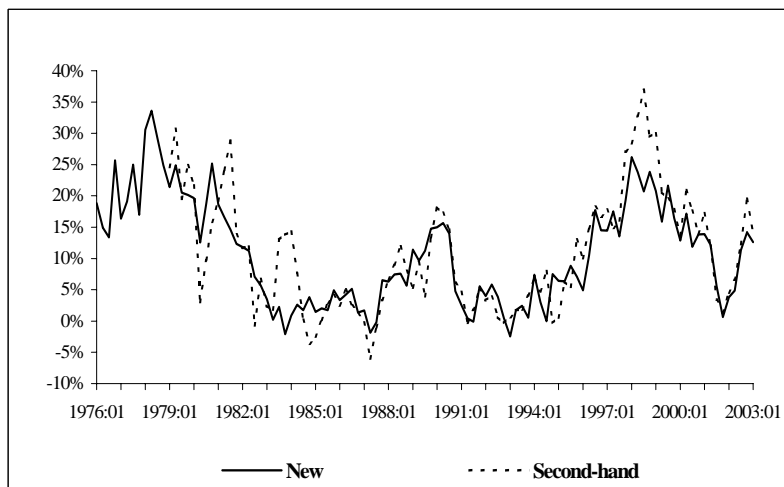
assets in a continuous process, with the initial rise generating expectations of further rises and attracting new buyers – generally speculators interested in profits from trading in the asset rather than its use or earning capacity. The rise is usually followed by a reversal of expectations and a sharp decline in the price often resulting in financial crisis”.

Figure 1: Nominal Irish House Prices



Unfortunately, we do not have a long historical run of data on repeat sales or on the length of time people hold on to houses between sales. Instead we have to estimate the fundamental value of a house and analyse the dynamics of the difference between the actual price and this fundamental value or what we label the non-fundamental price. Thus it is crucial to model fundamentals correctly.

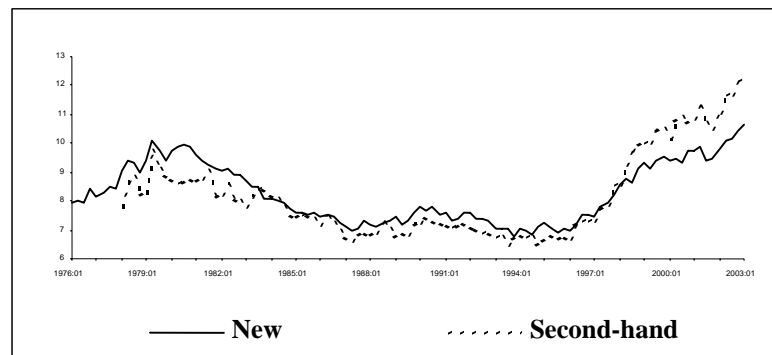
Figure 2: Nominal Irish House Price Inflation



It is not apparent from Figure 1 that Ireland has experienced such large percentage increases in the past. In Figure 2 it is evident that in the late 1970s and early 1980s average house price inflation was similar to current rates. Despite the very large increases in house

prices in the late 1970s and early 1980s no crash occurred. *The Economist* suggests that a worrying trend is that the ratio of house prices to disposable income per capita has risen sharply in the last seven years (see Figure 3). But for new house prices this ratio was almost as high in the late 1970s as it is today. In its May 2003 edition, *The Economist* based its pessimistic predictions for Irish house prices on this ratio alone. The International Monetary Fund (2003) use other demand factors but ignore the supply side in determining the long-run equilibrium value of a house. We will show that the fundamental or long run equilibrium value of a house depends on factors that affect both demand and supply.

Figure 3: House Price/Disposable Income Per Capita Ratio



In Figure 4 the trends in typical factors that affect demand are illustrated. The data are indexed so that the first quarter of 1980 is equal to 100.² Demographics always play a role in the demand for housing. The population level (or those aged between 25-44 years) is a commonly used series. However, Ireland has undergone a major demographic change with an influx of a large number of net immigrants since 1995 from -2,000 to a net inflow of approximately 30,000 in 2002. Nominal disposable income has risen sharply since 1995, by 87 per cent, and mortgage rates have fallen by half to all time lows. These two factors are partially reflected in the fact that loans paid out by the lending institutions for the purchase of new houses has also sharply increased since 1995, by 210 per cent. However, these loans have increased at an even faster rate than new house prices and this is reflected in the fact that the loan-to-value ratio has increased from 64 per cent in the first quarter of 1995 to over just over 68.5 per cent by the first quarter of 2003.

² The data on house prices, loans and completions are available from the *Housing Statistics Bulletin* published by the Department of the Environment and Local Government. The data on consumer prices, mortgage rates, disposable income, population, net migrants, and building costs are available from the Central Statistics Office. The data on land costs are available from the *Construction Industry Review and Outlook*. In the statistical analysis section of this article this variable is marginally better at explaining house prices than the level of the population. NCB Stockbrokers (2003) also make this point.

Figure 4: Demand Side Factors

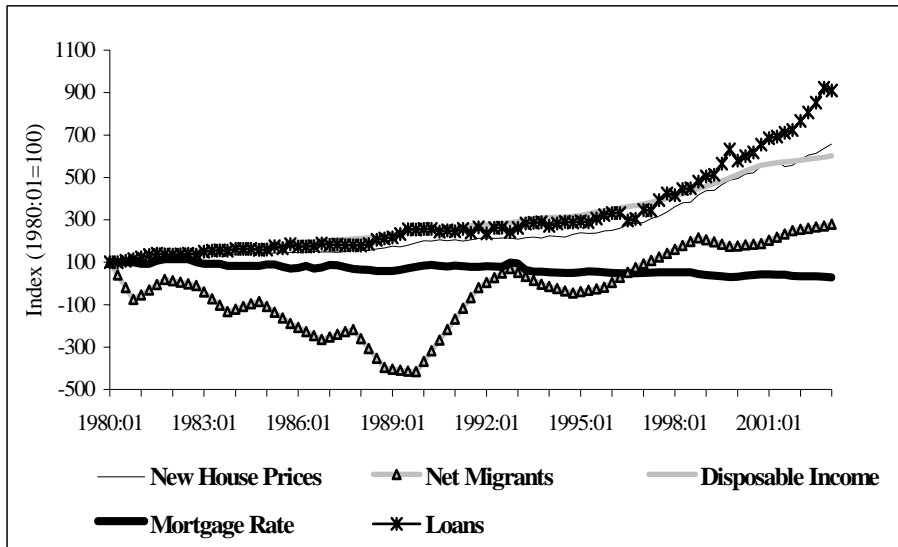
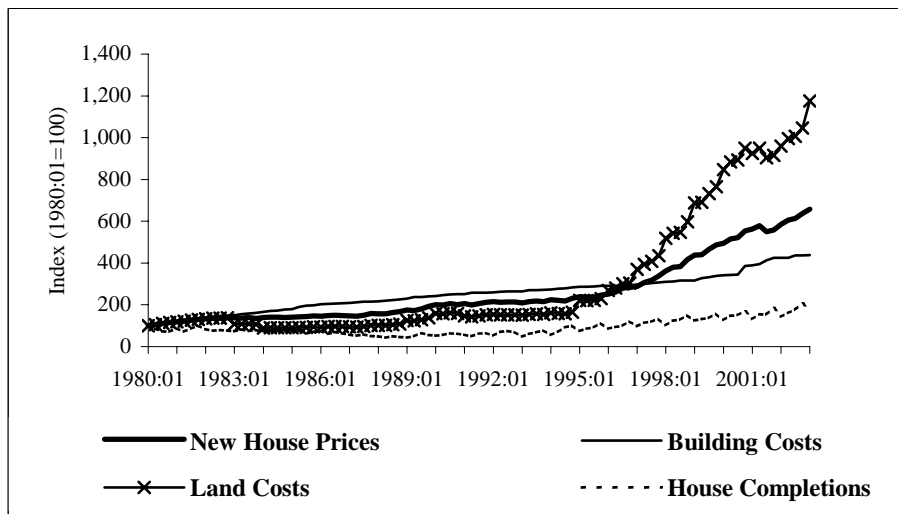


Figure 5: Supply Side Factors



Thus far we have looked at the demand side factors. Research by *The Economist* and the International Monetary Fund has only used some of these factors to model house prices. They ignore the supply side assuming that the supply of housing is perfectly inelastic. While that might be true in the short run, fundamental values depend on the long-run equilibrium and in the long run the supply of housing in Ireland is not perfectly inelastic.³ Therefore, factors affecting supply must be included in any model of house price fundamentals. The trends in these factors are presented in Figure 5 where the data are indexed so that the first quarter of 1980 is equal to 100. It is evident that building costs (exclusive of land costs) have increased

³ According to *Census 2002* there are fewer than 1.28 million dwellings in Ireland and the building industry produces over 60,000 new houses per annum. This represents about 5 per cent of the housing stock.

since 1995, up by 53 per cent. What is alarming in this figure is that development land prices have increased dramatically since 1995. In 1995 land was approximately 13 per cent of the price of new house and it is now 23 per cent. This represents an increase of 429 per cent between 1995Q1 and 2003Q1 in cost of the land component of the house price.

The trends presented here suggest that all supply and demand factors are moving in a direction that would increase price. Both supply and demand curves have shifted upward. As a result of this new house prices have increased by 175 per cent and the total number of houses built was 365,821 (or over a quarter of the housing stock) over the current boom period 1995Q1-2003Q1. Perhaps the recent rise in Irish house prices is not due to a speculative bubble as some would think but simply reflect major changes in supply and demand fundamentals. We analyse this with a variety of statistical techniques in the next section.

3. Analysis

Much analysis on the Irish housing market mentioned in the introduction focuses on the price of second-hand houses and use only factors affecting demand to model fundamental values. We argue that one should use new house prices and model the fundamental value using factors that affect both demand and supply. A quick glance at Figure 1 reveals that since 1996 the price of second-hand houses has increased at a faster pace than the price of new houses. This difference probably reflects a premium for urban living. Yet this factor is hardly ever included in the econometric model for second-hand house price (see International Monetary Fund (2003) for example). The second-hand house price to disposable income per capita ratio is currently much higher than the ratio calculated using new house prices. This in turn has led to researchers for *The Economist* to overestimate the extent to which house prices may be overvalued. They do not use an econometric model but measure overvaluation by simply calculating how much the house price to disposable income per capita ratio in 2002 is above its average for the 1975-2002 time period. Using this measure we calculate that second-hand houses are overvalued by 42 per cent and new houses are overvalued by 23 per cent. We contend that even 23 per cent is an overestimate.

A simple way to analyse the interaction between new and second-hand house prices is by way of a Vector-Autoregression (VAR) model.⁴ In a sentence, a VAR model relates both new and second-hand house prices to their lagged values. The 2003 Nobel Laureate Professor Clive Granger developed a simple econometric test, based on the VAR model, that determines whether movements in one variable cause movements in another variable. We estimate the model using quarterly data over the period 1979Q1-2003Q1. The results from the Granger-causality tests imply that real new house prices caused real second-hand house prices but not vice versa. The intuition for this result is simple. Changes in building and land costs

⁴The technical details are described in detail in the Appendix.

affect new house prices directly, and second-hand house prices indirectly via the market for new houses. Changes in demand factors affect the price of both new and second-hand houses directly. The models of house price fundamentals suggested by the International Monetary Fund and *The Economist* use second-hand house prices and ignore supply side factors. These models produce estimates of fundamental house prices for 2002 that suggest overvaluation of anywhere in the region of 16.5-50 per cent. Statistical evidence presented below suggests that this is not the case.

(A) MEASURES OF OVERVALUATION OF IRISH HOUSE PRICES

On the basis of the results from the VAR model, analysis is performed using new house prices. A reduced form equation from a basic supply and demand model of the housing market is used to estimate the fundamental price. This equation would relate real new house prices to independent demand factors such as new migrants, the user cost, real disposable income, the real value of home loans, and independent supply factors such as real building and land costs. A trend term is included to pick up other factors such as household formation. We first estimated the equation by Ordinary Least Squares (OLS) using quarterly data for the period 1979Q1-2003Q1. The starting observation is determined by the fact that land cost data are only available since 1979Q1. The estimated coefficients are presented in Table 1.

Our results indicate that both demand and supply factors are all statistically significant at conventional levels and have the expected sign (an increase in any factor except the user cost will increase real new house prices). Since the units of measurement are different for some of the variables (e.g. house prices are measured in thousands of euro and the user cost is measured in annualised percentages) the standardised coefficients, presented in square parenthesis, are easier to interpret. These coefficients are those estimated when all of the variables have been transformed to have a mean of zero and a variance of one. The standardised coefficient for land costs (0.55) is estimated to be almost double that of the next largest standardised coefficient (on real disposable income per capita), which implies that this factor is the most important explanatory variable for real new house prices.

One may worry about the fact that land costs may be endogenous. In other words changes in new house prices cause changes in land prices and vice versa. We explore this issue a number of ways. First, we performed a Durbin-Wu-Hausman test on the land cost variable using a constant, trend and all explanatory variables lagged one period as instruments. The probability value of the test statistic is 0.16 suggesting that land costs are not correlated with the reduced form equation error term and can therefore be treated as an exogenous variable. Second, we estimated a simple a VAR model relating both real new house prices and land costs to their lagged values. We estimate this model using quarterly data over

the period 1979Q1-2003Q1.⁵ The results from the Granger-causality tests imply that real land costs caused real new house prices but not vice versa. This also suggests that land costs could be treated as exogenous in a model explaining new house prices.

The reduced form equation happens to be a long-run cointegrating relationship between house prices and supply/demand factors (discussed in the next section). In this case the OLS coefficient estimator is superconsistent. The possible endogeneity of some of the explanatory variables will cause second order asymptotic bias in the coefficient estimates that may be important in small samples (though not in large samples). One way to correct for this is to estimate the model using fully-modified OLS (see Phillips and Hansen (1990)). The FM-OLS estimates are presented in the third column of Table 1. The estimated coefficients are not much different than those estimated using OLS. We cannot reject the hypothesis that coefficients estimated by OLS are the same as those estimated by FM-OLS using the FM-OLS coefficient standard errors. Thus all three methods suggest that land costs can be treated as exogenous in a model of new house prices and we will continue our analysis using the OLS estimated coefficients.

Table 1: Estimated Reduced Form Model for Real New House Prices

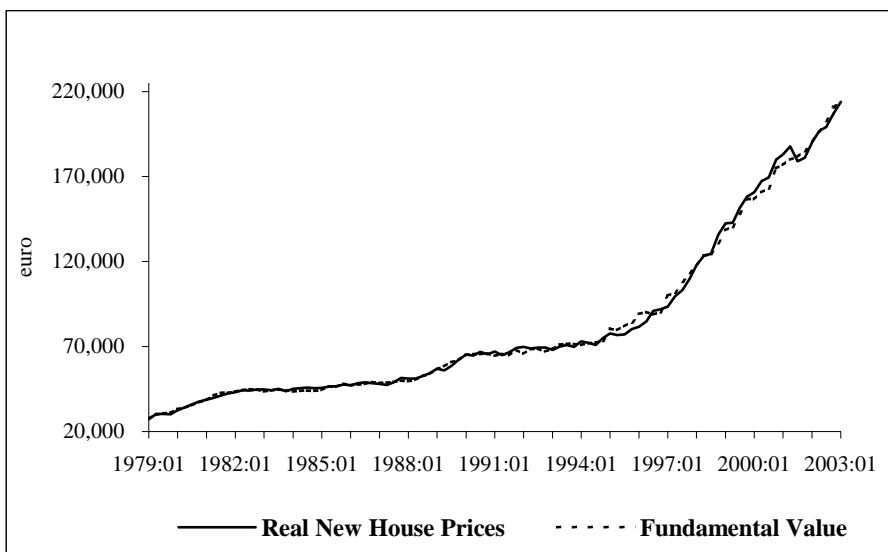
	OLS	FM_OLS
Constant	11.21 (1.52)	4.08 (0.24)
Trend	-0.26 (5.00)	-0.28 (3.48)
Builders Costs (excluding land)	0.17 [0.06] (2.60)	0.20 (1.97)
Land Costs	1.64 [0.55] (10.80)	1.60 (6.98)
Net Immigrants	0.09[0.04] (4.21)	0.11 (3.69)
Loan Amount	0.33 [0.22] (5.83)	0.37 (4.35)
User Cost	-0.12 [-0.03] (3.21)	-0.06 (1.07)
Disposable Income per capita	3.31 [0.28] (3.89)	3.15 (2.46)

Note: Absolute t-statistics are in round parenthesis. Standardised coefficients are in square parenthesis. The data are measured in thousands with the exception of building costs which is an index and user cost which is in percentages.

The fitted value for this model can be interpreted as the fundamental value. The actual and fundamental values are presented in Figure 6. One can see the model fits real new house prices very well (adjusted R² is 99 per cent). The difference between the two series can be interpreted as a non-fundamental price or a measure of under/overvaluation. In order to compare measures of overvaluation in 2002 based on this model with those of the International Monetary Fund (2003) and *The Economist* (2003) discussed in the introduction we estimate two other models of house prices.

⁵ The technical details are described in detail in the Appendix.

Figure 6: Real New House Prices and their Fundamental Values



The first model, follows International Monetary Fund (2003), and relates real second- hand house prices to real disposable income, real mortgage rates and the young house buying population as a percentage of the total population. The second, model relates real second-hand house prices to real disposable income per capita. We note that while *The Economist* (2003) did not estimate a regression equation, disposable income is the variable they base their analysis on. The purpose here is to demonstrate that only using this factor to model fundamentals will produce the result that house prices are considerably overvalued.

We estimate each model for the period 1979Q1-2003Q1 and calculate how much Irish house prices are overvalued in 2002. This measure of overvaluation is based on the within-sample forecast errors (or residuals). The estimated response of house prices to fundamentals could be biased if many observations are coming from a bubble period as the International Monetary Fund (2003) correctly suggest. Thus we follow the researchers at the International Monetary Fund and each model is also estimated using data from the period 1979Q1-1997Q4. The estimated coefficients are used to make forecasts for 2002. In this case the measure of overvaluation is based on the out-of-sample forecast errors. These techniques were also used in Bacon, MacCabe and Murphy (1998) and Bacon and MacCabe (2000). The results are presented in Table 2. We find that when we use only demand factors to explain house prices, they are overvalued by at least 11 per cent and could be 75 per cent! The International Monetary Fund (2003) and *The Economist* (2003) report estimates of overvaluation of Irish house prices that are in this very broad range. Our measures of overvaluation in 2002 are in a very narrow range of 0.2 per cent-4.6 per cent. Thus Irish house prices are more or less at fundamentals according to our model that uses supply and demand factors as explanatory variables. Based on a model that accounts for both demand the supply factors the International Monetary Fund and *The Economist's* measures

exaggerated the overvaluation of house prices. Their estimates are biased upwards as a result of omitting important explanatory variables in their models of house prices.

Table 2: Measures of Overvaluation of Irish House Prices for 2002

Based on	The IMF	The Economist	Demand/Supply Factors
Within-sample forecasts	11.1%	13.3%	0.2%
Out-of-sample forecasts	75.4%	56.1%	4.6%

Note: The figures for 2002 are the average of the estimated value in each of the four quarters.

(B) TESTING FOR A BUBBLE IN IRISH HOUSE PRICES

We now examine whether *The Economist's* suggestion that there is a bubble in the market is realistic. Assuming that using supply and demand factors as explanatory variables is the appropriate way to model house price fundamentals, we further investigate whether there is or has been a bubble in the Irish housing market. In late 1998 the Irish Central Bank suggested that a property bubble existed. Similar comments were also made in the first Bacon Report. 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. Such a tendency, if left unchecked, could develop into a speculative bubble.” Roche (1999) compared the Irish market in the late 1990s to that of Britain in the late 1980s. His findings suggested that there was statistical evidence of a speculative bubble in house prices in both countries at those time periods. He estimated that the probability of a house price crash in Britain had reached its highest value in the last third quarter of 1989, a quarter before the British housing market crash. However, Roche (1999) estimated that the probability of a crash in the Irish housing market had always fluctuated between zero and 2 per cent between 1978-1998 and concluded that an imminent crash was unlikely.

We test for bubbles in the housing market using three methodologies. In each case we estimate fundamental values using both demand and supply factors mentioned above. The first method is based on the estimated model using data for the period 1979Q1-1997Q4. We forecast real house prices for the next 21 quarters. We find that the out-of-sample forecast errors for the period 1998Q1-2003Q1 are jointly significantly no different than zero, although some individual t-tests are significant. We also estimated the model using data for the period 1979Q1-1999Q4 and repeated the exercise. We found that the forecast errors are both jointly and individually insignificant. These results are suggestive that there may have been a bubble in the market in late 1990s. Bacon and MacCabe (2000) adopted a similar approach. Their out-of-sample forecast errors increased from 1996-2000 and they suggested that a “speculative/transitory factor could have contributed significantly to the level of housing demand by 1999”. However, land costs are omitted from their model of house prices.

The other two tests for a price bubble in the housing market involve the time series properties of the non-fundamental price (or

measure of overvaluation). If a bubble exists in the market then the non-fundamental price will not be a stationary time series, it will be explosive. In this case house prices will not be cointegrated with fundamentals. In other words there will be no apparent long-run relationship between house prices and fundamental demand and supply factors. The 2003 Nobel Laureates Professors Clive Granger and Robert Engle developed a simple econometric test for cointegration. We find that house prices are cointegrated with demand and supply fundamentals using data for the period 1979Q1-2003Q1.⁶ This suggests that there is no bubble in Irish house prices.

Evans (1991) has shown that the test for price bubbles based on cointegration is not very powerful if there is a partially collapsing bubble in the market. The partially collapsing bubbles model of Blanchard and Watson (1982) describes such a situation. During a sharp fall in price the government intervenes in the market and stops the price from crashing to or below fundamentals, thus the bubble partially collapses. For example, in a currency crisis the government may intervene and buy the currency. In Ireland, the government reversed its policy on stamp duty at the end of 2001 in response to the dramatic slowing down of the market during that year. This brought investors back into the housing market and prices have started to rise again.

The partially collapsing bubble phenomenon can be captured in a regime-switching econometric model developed by van Norden (1996).⁷ The basic idea is that the sample can be split into two regimes. The regimes are where the variance of house price changes is low (when the bubble survives) or high (when there is a partial crash). The pattern of low and high variance of house price changes is evident in Figure 2. For example house price inflation is much more volatile at the beginning (1976-1982) and end (1996-2003) of the sample period than it is in the intervening years (1983-1995). This model nests three types of dynamic behaviour of house prices as special cases. One is that of a partially collapsing bubble. The second type of behaviour is that of a fad. The housing market is said to be displaying a fad if the actual price has tendencies to be above (or below) the fundamental price for long periods of time but eventually revert to the fundamental price. A fad in the market produces a gentler rise and subsequent fall in prices than a bubble. The third type of behaviour is that the housing market is efficient. In this case house prices would fluctuate randomly around fundamental values.

We estimated the regime-switching model for the period 1979Q1-2003Q2. Using a likelihood ratio test we cannot reject the null hypothesis that the fads model can represent data at the 5 per cent significance level. Our findings, discussed in detail in the Appendix, suggest that there is no bubble in the market. These

⁶ All variables with the exception of net migrants were found to be integrated of order 1. Thus the reduced form equation can be interpreted as a long-run relationship if variables are cointegrated. We tested the residuals for a unit root using the Engle and Granger (1987) test and in the test regression we included lags of the change in the residuals based on reduction methods. The t-statistic was -6.25 and we conclude that these variables are cointegrated.

⁷ The technical details are described in detail in the Appendix.

results further support the findings from the tests based on out-of-sample forecasting and based on cointegration. In our opinion the suggestion made by *The Economist* (2003) that there currently is a price bubble in the Irish housing market has no statistical support.⁸

4. Conclusion

In this article we evaluate recent comments on house prices made by *The Economist* and the International Monetary Fund. They suggested and produced some statistical evidence, that house prices were considerably overvalued. Some commentators have suggested that there is a bubble in the housing market and that a major fall in house prices was on its way. We find that this is not the case if supply factors are included in the model for fundamental house prices. The results from our research suggest that currently new house prices are more or less at their fundamental values.

We also find that while there may have been a speculative bubble in the housing market in the late 1990s, it has disappeared. The cooling of the housing market may be partly due to the government policy of raising stamp duty on non-owner occupiers and to the recent economic downturn. However, in 2002 the government has reversed its policy on stamp duty and as the International Monetary Fund point out this could induce more volatility in the housing market. Finally, our results suggest that land costs are an important factor in the recent rise in new house prices. It is here the government should focus their immediate attention.

APPENDIX

The Vector-Autoregression (VAR) model

The first statistical model used in this article is the following vector autoregression of order p (VAR(p))

$$\mathbf{X}_t = \mathbf{A}_0 + \mathbf{A}_1 \mathbf{X}_{t-1} + \mathbf{A}_2 \mathbf{X}_{t-2} + \dots + \mathbf{A}_p \mathbf{X}_{t-p} + \mathbf{U}_t \quad (1)$$

where \mathbf{X}_t is a vector containing two series at time t , new and second-hand house prices deflated by the consumer price index, the \mathbf{A}_i are coefficient matrices and \mathbf{U}_t is an error vector that is distributed as multivariate normal. We estimated the model using quarterly data for the period 1979Q1-2003Q1. We first used standard information criterion to determine the appropriate lag length p . The Akaike Information Criterion (see Akaike (1974)) suggested that $p=4$ and the Schwarz Bayesian Criterion (see Schwarz (1978)) suggested that $p=1$. Since these results are inconclusive as to the value of p we

⁸ We also estimated the regime-switching model for the period 1979Q1-1998Q4 (as in Roche (1999)). The results, available upon request, are similar to those reported by Roche (1999) and indicate that there is some statistical evidence of a speculative bubble in new house prices for this period. These results further support the finding that while there may have been a bubble developing in the late 1990s the market has since cooled down and prices are reverting back to fundamentals.

performed a Likelihood Ratio test. The null hypothesis is that the VAR is of order 1 and the alternative hypothesis is that the VAR is of order 4. The P-value was less than 0.01. Thus we estimated a VAR(4) model and report the Granger-causality F-tests in Table A1. We found that new house prices Granger-caused second-hand house prices but not vice versa.

Table A1: The P-values of Granger-causality tests from a VAR of Irish House Prices

Dependent Variable	Independent Variable	
	New House Prices	Second-hand House Prices
New house prices	0.00	0.00
Second-hand house prices	0.19	0.00

We also estimated the model using quarterly data for the period 1979Q1-2003Q1 where the \mathbf{X}_t vector contained new house prices and land costs deflated by the consumer price index. We used standard information criterion to determine the appropriate lag length p . The Akaike Information Criterion (see Akaike (1974)) and the Schwarz Bayesian Criterion (see Schwarz (1978)) suggested that $p=8$. Thus we estimated a VAR(8) model and report the Granger-causality F-tests in Table A2. We found that land costs Granger-caused new house prices but not vice versa.

Table A2: The P-values of Granger-causality tests from a VAR of Irish House Prices and Land Costs

Dependent Variable	Independent Variable	
	New House Prices	Land Costs
New house prices	0.00	0.18
Land costs	0.00	0.00

The Regime-Switching model

We present a brief outline of the regime-switching model in this section. This model captures the essence of the partially collapsing bubbles model of Blanchard and Watson (1982). See van Norden (1996) for a full discussion on the model. He assumes that:

1. There are two states of nature, one a state in which a bubble collapses, labelled C, and the other a state in which the bubble survives, labelled S;
2. The probability being in regime S is q ;
3. The probability of the bubble's continued growth falls as the bubble grows and;
4. The bubble is expected to partially collapse in state C where the expected size of the collapse depends on the relative size of the bubble to the fundamental price.

The general regime-switching model that incorporates these assumptions is given by

$$\begin{aligned}
\Delta P_t &= \beta_{s0} + \beta_{s1}P_{t-1}^{nf} + e_t, \quad e_t \sim N(0, \sigma_s^2) \quad \text{with a probability of } q \\
\Delta P_t &= \beta_{c0} + \beta_{c1}P_{t-1}^{nf} + e_t, \quad e_t \sim N(0, \sigma_c^2) \quad \text{with a probability of } 1 - q \\
\text{Prob}(\text{State at time } t = S) &= q(P_{t-1}^{nf}) = \frac{1}{1 + e^{-(\beta_{q0} + \beta_{q1}(P_{t-1}^{nf})^2)}}
\end{aligned}
\tag{2}$$

where ΔP_t is the current change in real new house prices and P_{t-1}^{nf} is last quarters measure of the non-fundamental price level (or bubble if one exists). The latter is estimated as the residual (or overvaluation) from the reduced-form model discussed in the article. The probability of the bubble surviving, q , is bounded between 0 and 1 using the Logit function. The general regime-switching model nests many models as special cases. In all of these cases the shocks generating the change in house prices are assumed to be from a mixture of normal distributions with different means and variances. This allows for heteroscedastic errors.

If the restrictions $\beta_{s1} = \beta_{c1} = \beta_{q1} = 0$ hold, then house prices fluctuate randomly around their fundamental values. In this case there is no bubble or fad in the market. We call this the Efficient Market Model. If the restrictions $\beta_{s0} = \beta_{c0} = \beta_0$, $\beta_{s1} = \beta_{c1} = \beta_1 < 0$, and $\beta_{q1} = 0$ hold, then non-fundamental house prices are mean reverting. In this case there is a Fad in the market. A fad in house prices is different than a bubble in the sense that the price rise and fall is much more gradual and the price peak is closer to fundamental values. If the restrictions $\beta_{s0} \neq \beta_{c0}$, $\beta_{s1} > 0 > \beta_{c1}$, $\beta_{q1} > 0$ and $\sigma_c > \sigma_s$ or $\beta_{s0} \neq \beta_{c0}$, $\beta_{s1} < 0 < \beta_{c1}$, $\beta_{q1} < 0$ and $\sigma_s > \sigma_c$ hold, then the data can be described by a Partially Collapsing Bubbles model. In this model there is a period when a speculative bubble exists and is growing. As the bubble grows the probability of a collapse increases. This is an assumption based on many historical accounts of speculative periods.

Since we have assumed that the errors generating house price changes, e_t , have normal, independent and identical distributions, the log likelihood function for the general regime-switching model is given by

$$\sum_{t=1}^T \ln \left[(1 - q(P_{t-1}^{nf})) \cdot \frac{\varphi\left(\frac{\Delta P_t - \beta_{c0} - \beta_{c1}P_{t-1}^{nf}}{\sigma_c}\right)}{\sigma_c} + q(P_{t-1}^{nf}) \cdot \frac{\varphi\left(\frac{\Delta P_t - \beta_{s0} - \beta_{s1}P_{t-1}^{nf}}{\sigma_s}\right)}{\sigma_s} \right]
\tag{3}$$

where φ is the standard normal probability density function. We can use the model to explore historical accounts of the speculative periods. The conditional probability of a crash in house price in the next period can be calculated as

$$\Pr(\Delta P_t < x) = (1 - q(P_{t-1}^{nf})) \cdot \frac{\varphi\left(\frac{x - \beta_{c0} - \beta_{c1}P_{t-1}^{nf}}{\sigma_c}\right)}{\sigma_c} + q(P_{t-1}^{nf}) \cdot \frac{\varphi\left(\frac{x - \beta_{s0} - \beta_{s1}P_{t-1}^{nf}}{\sigma_s}\right)}{\sigma_s} \quad (4)$$

where x is a house price change two standard deviations below average house price changes.

We estimated the model for the period 1979Q1-2003Q2 and the results are presented in Table A3. We performed some likelihood ratio tests. We tested whether the General Regime-Switching fits the data better than either the fads model with variable q or the Efficient Market model with variable q . We also tested whether the General Regime Switching fits the data better than any model with constant q . We rejected each null hypothesis except one. At the 5 per cent significance level we cannot reject the null hypothesis that data can be represented by the Fads model with constant q . This suggests that there is no bubble in the housing market and that prices revert to fundamentals. In addition the signs on the estimated parameters do not conform to those predicted by the Partially Collapsing Bubbles model.

Table A3: Estimated General Regime-Switching Models

Probability Values for the Likelihood Ratio Tests	
Fads model with variable q	0.01
Efficient market model with variable q	0.01
Bubbles model with constant q	0.02
Fads model with constant q	0.06
Efficient market model with constant q	0.01
<i>Parameter estimates</i>	
β_{s0}	-0.68 (1.49)
β_{c0}	2.00 (3.80)
β_{s1}	0.46 (1.32)
β_{c1}	-0.77 (4.09)
β_{q0}	1.23 (1.74)
β_{q1}	0.29 (1.82)
σ_s	1.33 (3.26)
σ_c	3.47 (10.44)

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.

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