Modelling Housing Market Fundamentals: Empirical Evidence of Extreme Market Conditions[*]

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Abstract

This paper examines the issues encountered in the modelling of market fundamentals during a period of extreme price behaviour. The study analyses the price behaviour of the residential property market in Ireland using a number of alternative methodological approaches in the estimation of fundamental value in the market. Limitations in conventional models such as an inverted demand model are highlighted, in particular with regard to diagnostic concerns and the static nature of the model. The use of an Error-Correction Framework provides more consistent and robust findings. The analysis does appear to indicate that a substantial premium over fundamental values developed in the Irish market during the late nineties, reaching a peak in 1999 and 2000. While this speculative premium did decrease in 2001, the majority of the models used signify that a substantial premium over fundamental values is still present in the market.

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1: Introduction

A large number of housing markets globally have witnessed substantial increases in prices in recent years, leading to growing concerns over the sustainability of current prices. Price increases of the magnitude observed in recent years bring to light some limitations with many of the conventional methods of modelling fundamentals in housing markets. This paper examines the extent to which alternative modelling approaches can adequately capture such price movements and the robustness of such models. The empirical analysis is undertaken on the Irish market, a market that has frequently been highlighted with suggestions of the development of a speculative bubble. The Irish market is modelled using a number of alternative methodological approaches. The first approach is an inverted demand model, as used in previous studies such as Muellbauer & Murphy (1997). This model has a number of potential limitations in its use in such market conditions. Firstly, it is estimated in log level form, therefore potentially encountering difficulties due to stationarity issues and cointegration between the variables. Secondly, its static nature highlights issues with regard to the estimation period used. An alternative approach is to use an error-correction framework. A further alternative to the error-correction approach is the model proposed by Abrahams & Hendershott (1996). The final model is the asset-based approach of Levin & Wright (1997).

The level of price increases in the Irish housing market since the mid-nineties has created considerable debate as to whether a speculative bubble has developed and the likelihood of a crash of some magnitude in the market. The level of increase can be seen by the fact that on a national basis, average second-hand home prices increased by 307% over the period 1994 to 2003. Substantial increases were observed across all regions. While price increases were highest in the Dublin market, with price increases of 361% in this nine year period, even the 'worst' performing market, Limerick, saw increases in average second-hand house prices of 272%. Given the importance of housing in a macro-economic context, the risk of a crash to perceived more sustainable levels would have a major impact upon the Irish economy.

Many commentators have spoken of a large possible correction in the market and the potential impact upon economic output and household wealth. The Economist in May 2003 argued that due to the rising ratio of prices to income a correction of the magnitude of 20% was likely by 2007. In addition, domestic commentators have often warned about the dangers of negative equity in the market, particularly in Dublin, and the ensuing dangers and problems that would subsequently arise. However, commentaries may not fully take into account factors such as

the equity built up in housing since the mid-nineties. As of the second quarter of 2003, average second-hand prices across the country stood at €267,646. A 20% correction of the type speculated by The Economist would reduce average values to only €214,000, which is in excess of average prices reported by the Department of the Environment, Heritage & Local Government even in the first quarter of 2002. In addition, many commentators have confused or merged the issues of justifiable values and affordability problems. Given the strong economic growth in the Irish economy over the last decade and the equity built up in property during the boom, it may well be that prices can be justified in an economically based fundamental sense. This does not however, preclude the fact that affordability is an increasing problem in the market and particular in markets such as Dublin.

Cyclical behaviour in the housing market differs substantially from that commonly seen in the capital markets. While the residential property market, in common with the commercial sector, is prone to the impact of demand shocks due to the supply restrictions that are a natural feature of real estate, this alone does not explain the boom-bust cycles that are frequently observed worldwide. In addition, constraints in the shape of factors such as high transaction costs also limit what is viewed as conventional speculative behaviour. Finally, owner-occupiers, whose property decisions tend not to be driven by profit motives, undertake most house purchases. However, these factors can actually encourage speculative behaviour. As Levin & Wright (1997) note, given that owner-occupiers dominate the market, transaction costs do not act as a barrier if an owner-occupier, or indeed a first-time buyer, intends to move house anyway. In addition, many households have the perception, particularly during a strong up-turn in a market, that housing provides them with their best opportunity to increase wealth. This is particular so given that for most households their home will be their largest asset. A further factor, that is especially present during strong upward movements in the market, is the perceived implicit cost of not entering the market either for the first time buyer or in terms of an existing owner occupier trading up. Despite the evidence present that illustrates the neutrality that should be present in the choice of tenure (see Ben-Shahar, 2004), in markets such as Ireland there is a strong preference for owner-occupation. At present approximately 80% of homes in the Irish Republic are owner-occupied, one of the highest owner-occupation rates in Europe. Given this strong preference for ownership over renting, the importance of the perceived cost of missing out on a strong upward market will also heavily influence housing decisions.

The contrast in investor behaviour between the housing market and the capital markets highlight a key element in the analysis of housing markets. Whilst in the capital markets prices are determined largely by rational investors, this is not so in the residential property

markets. The fact that prices are effectively determined by largely uniformed investors has the implication that their expectations cannot be described as rational, and tend to place great importance on past movements in market prices. This effectively means that the role of past prices, particularly during a period felt to display the characteristics of a bubble, is one of an expectations operator, rather than a measure of fundamental value. This argument concerning expectations has been described in papers such Poterba (1991) in terms of investors in the housing market having extrapolative expectations.

The remainder of the paper is laid out as follows. The following section provides details on market conditions in the Irish market and in particularly some of the key underlying fundamentals, both economically and demographically. Section 3 details the data requirements in the paper. The empirical analysis is broken into two main sections. The first section discusses the estimation of the alternative models used, highlighting methodological concerns. The second part of the empirical analysis, Section 5, examines the speculative element in the market based on the above models and examines the estimated premiums over fundamental value. The final section of the paper provides concluding comments.

2: The Irish Residential Market

Any examination of the housing market in Ireland during the last decade has to be placed in the context of the economic and demographic shifts that occurred during this period. Charts 1 and 2 illustrate the price in average second hand homes nationwide in both nominal and real terms. As can be seen, with the exception of 2001, prices have risen consistently in both nominal and real terms to a dramatic extent over the last decade. As noted in the introduction, prices in nominal terms increased by 307% from the fourth quarter of 1994 to the corresponding period in 2003. The features evident in Chart 2 illustrate the unusual characteristics present in the dynamics and behaviour of the Irish housing market since the early eighties. As can be seen, in real terms prices actually declined in the early eighties and did not regain their real value until the mid-nineties. In modelling terms this also creates interesting problems, given the virtually stationary series present for the first fifteen years of the sample period, and the sharp upward movement in the last decade. Given the level of price increases observable during the late nineties it is natural to conclude that some form of speculative bubble has been present in the market. However, this would be to ignore the strong economic performance of Ireland during this period and also a number of significant demographic shifts that would contribute to price increases.

{Insert Charts 1 & 2}

In relation to economic conditions the scale of the economic growth observed during the 'Celtic Tiger' years is perhaps often not fully appreciated. The magnitude of the economic growth can be illustrated by statistics such as the following: Real GDP grew by 137% between 1990 and 2003 and 88% from 1995, while total employment grew by over 54% from 1991 to 2003 to 1,799,801 from 1,165,000. This strong growth was influenced by a number of factors such as a corporate friendly tax regime, high levels of foreign direct investment, the view of Ireland as a pro-European English speaking country and historically low interest rates. However, in the context of the housing market, demographic shifts have perhaps been of equal importance, although in many cases linked to the economic performance. Ireland changed from a position of net emigration during the eighties and early nineties to one of net immigration during the mid to late nineties. The eighties saw overall net emigration of 172,016, in large part due to the poor economic conditions and employment prospects available domestically. As economic conditions improved not only did the movement of Irish overseas slow, but in addition, many of those who had emigrated in the previous decade started to return. The period 1995 to 2003 saw total net immigration of 174,901. In addition to this migration affect, the country also saw a large natural increase in the prime first-time buyer age group, with population growth in this age group out-stripping the overall population growth. While the overall population grew by 11.53% to 3.91m during the nineties, the 25-44 age range grew by 23%. This resulted in an increase in the percentage of the population in this age group to a figure of over 30%. The natural increase was also influenced and enhanced by the impact of immigration, with official estimates that 40% of immigrants were in the 25-44 age group, with immigration accounting for 43.5% of overall population growth.

A growing number of studies have examined aspects of the housing market in Ireland in recent years, with the majority concentrating on the estimation of fundamental value[1]. The majority of these have adopted a standard inverted demand model in their analysis, for example; Bacon et al. (1998), Bacon & MacCabe (2000), Brereton & Murphy (2001) and Stevenson (2003b). Bacon et al. (1998) model national second-hand house prices using real disposable income per capita, lagged real disposable income per capita, housing user cost and population in the 25-34 age group as a percentage of the total population. The data was based on annual data for the period 1974 to 1996. The results report an income elasticity of approximately 1.5, with all variables bar the contemporaneous observation for real personal disposable income per capita being significant. The model explains a high proportion of variation in house prices, with an adjusted R^2 of 0.86, while the model generally satisfies the diagnostic tests conducted.

Bacon & MacCabe (2000) provide an extension to this analysis with the benefit of three additional years of data. This analysis uses slightly different variables and examines house prices over the period 1972-1999. The variables used in the model are housing stock, lagged housing stock, personal disposable income, the mortgage lending rate, the population aged 25-34 and lagged second hand prices. The analysis estimates the equation twice, once using data up until 1996 and secondly using the entire data set. The purpose of this analysis was to see if recent price behaviour has changed the specification of the model and if differences are observed. It should be noted that in both models very few significant variables are observed. In the initial analysis up until 1996 only personal disposable income and the demographic variable are significant at conventional levels, while in the extended analysis only the income, mortgage rate and lagged price variables are significant. In addition, the report notes that diagnostic tests indicate instability in the estimates with the model failing a Chow structural stability test. The authors argue that the presence of a significant lagged price variable is an indication of increasing importance being placed on past price movements and so consistent with a speculative element emerging in the market. In addition, the income elasticity of the market appears to have risen considerably.

Brereton & Murphy (2001) also extend the analysis of Bacon et al. (1998), using the same variables as in Bacon et al. (1998) and observe instability in the coefficients, with a number of the variables previously reported as significant no longer being so. The authors estimate that the 1999 forecast error was approximately 24%. Stevenson (2003b) notes considerable diagnostic problems in his estimation of a demand model over the period 1978-2001 using annual data. The independent variables used in this study include population, real disposable income per capita, consumer confidence, per capita housing stock, employment and the user cost of capital. The results also highlight the issue of whether lagged housing prices or returns are suitable for inclusion in a model of fundamental behaviour. It is noticeable that the version of the model that includes lagged prices encounters far fewer diagnostic concerns and also reports more intuitive and significant coefficients. However, while the model is perhaps more intuitive and econometrically appealing, it can be argued that lagged prices merely represent an expectations operator and do not reflect underlying economic or demographic fundamentals. The estimated premium/discount over fundamental show a marked difference between the two alternative specifications, with the model that incorporated lagged prices showing only a sight premium in 1997 and then largely tracking actual market movements. These findings further support the results reported by Bacon & MacCabe (2000).

While the majority of studies have estimated an inverted demand equation Kenny (1999) and McQuinn (2004) adopt a different approach and model the market in a Vector Error-

Correction (VECM) framework. Kenny (1999) finds evidence of a long-run cointegrating relationship between housing and stock, aggregate income and interest rates. The paper also finds evidence of substantial supply constraints, which the author argues could be a major factor behind the bubble like characteristics of the market in recent years, with prices overshooting their long-run equilibrium. Roche (1999, 2001) and Stevenson (2003b) explicitly examine the speculative element in the market in the late nineties. Roche (1999) examines the national market, while Roche (2001) solely examines the Dublin market. Both papers use the Van Norden (1996) regime-switching approach in their assessment of market conditions. The results are generally consistent, finding evidence of a speculative component in both national and Dublin house prices in the late nineties. Roche (1999) estimated that the probability of a crash in the nationwide market rose to 2% in 1998 and that the non-fundamental price was approximately 10%. The paper also models the UK market to compare Irish house price behaviour to the British residential market in the late eighties-early nineties. The findings show that the non-fundamental price in Ireland and the probability of a crash was far lower than in the UK cycle. This would indicate that fundamentals are far stronger in the Irish market than in the UK during the previous cycle and therefore the rise in price is less speculatively driven and most justifiable. The results for Dublin, contained in Roche (2001), do not substantially differ. Indeed, they show that the probability of a crash has not substantially altered and is only slightly above the national estimates reported in Roche (1999). The results of Stevenson (2003b) broadly concur with this analysis, with the findings indicating that the speculative element present in the market reduced from 1999 onwards. Indeed, in some of the analysis both papers argue that by 2001 the market was largely back in equilibrium. The paper also examines markets outside of Dublin, finding evidence that speculative behaviour was more pronounced and started earlier in Dublin, indicating some form of house price diffusion[2].

3: Data:

The estimation of fundamental value is undertaken using a variety of model specifications. These will be discussed in further detail in the following section together with the presentation of the initial empirical results with regard to each specification. The data used in this study comprises of quarterly data for the period 1978 through 2003. The use of quarterly data differs from many of the previous studies of the Irish market that have used annual data (Bacon et. al., 1998, Bacon & Kenny, 1999, MacCabe, 2000, Brereton & Murphy, 2001 and Stevenson 2003b). Quarterly data allows the implementation of alternative methods of estimating fundamental value. For example, while Stevenson (2003b) used the Abraham & Hendershott (1996) model, he adopted the same approach used in Bourassa et al. (2001) and

examined the regional markets on a panel basis due to the limitations present in the annual sample size. The use of quarterly data allows the examination of the national market. The housing data consists of the second-hand data provided by the Department of the Environment, Heritage & Local Government. At present the historical data available merely consists of an average house price and is not weighted in any manner, or estimated through a hedonic model. While some hedonic based models do currently exist, they do not have sufficient time series history to be viable for use in the present analysis[3].

Initially a variety of data series were examined for suitability for the alternative models. With the exception of the Levin & Wright (1997) model, where the authors' original specification is used, the remaining fundamental models all use the same set of independent variables. The set contains a number of variables that have been frequently used in previous studies of the Irish market and are population in the prime first time buyer age group of 25-44, real disposable income per capita, housing stock per capita and the real after-tax interest rate. A number of alternative variables were also initially tested across all of the models used. With regard to demographic factors total population and net migration were also tested as well as population in the 25-44 age range. In all tests population in the 25-44 range performed best. This could well be due to the fact that this measure may not only be picking up overall demographic trends, but also more explicitly the migration effect. As noted in Section 2 the government estimate that 40% of immigrants were in this age range. Employment was also tested in addition to the population variables. Employment has been used in a number of studies examining speculative behaviour, including Bourassa et al (2001). As noted in the introduction, employment growth during the nineties exceeded 50%. Employment was therefore felt to provide not only a proxy for economic growth, but that it may also capture an element of the demographic trends in the country. However, the inclusion of employment, or the replacement of demographic variables with it, largely resulted in insignificant findings, variables of an unanticipated sign and diagnostic concerns.

Tests were also conducted using an estimate of the user cost of capital in preference to the real after-tax interest rate. The results with regard to user cost did not actually differ substantially in most cases from the use of the real rate. However, the primary reason behind the choice of the real rate was concerned with the composition of the user cost. As in previous studies, such as Muellbauer & Murphy (1997), the user cost was defined as the periodic mortgage rate less the appreciation rate in house prices. Given the issues discussed earlier in the paper concerning the role of past price movements as an expectations operator, the incorporation of such a variable was felt to potentially include in the final model some element of household's expectations[4]. Other variables that were also examined in the initial

tests before the final set was selected included building costs, consumer confidence, real disposable income per household, retail sales, industrial production and housing completions. All of the variables were obtained on a quarterly basis from the Irish Central Statistics Office, while real after-tax interest rates were estimated in a similar manner to Abraham & Hendershott (1996).

4: Estimation of Fundamental Models

4.1: Demand Model

The first form of model used in this study is a standard house price equation, which can be described as an inverted demand equation. This form of model has been used extensively in housing economics, particularly in the UK literature (see for example, Muellbauer & Murphy, 1997), and as noted in Section 2, the majority of studies of the Irish market in recent years have also adopted an inverted demand framework[5]. The approach is not without its detractors, as will be discussed later in the section.

The basis for inverted demand models can be described as such. Initially define the proportional demand for housing as:

$$H/POP = f(y, \mu, D) \tag{1}$$

Where H is the demand for housing, POP is a demographic indicator of some form, y is real income, μ is the user cost and D are other variables which are determined to impact upon demand. Given a definition of the user cost as:

$$\mu = P^h\left(r + \delta - P^{he}/P^h\right) \tag{2}$$

where P^h is real house prices, P^{he} is expected house prices, r is the interest rate adjusted for tax and δ is the depreciation rate. We can further define the rate of return as follows:

$$v = \left(r + \delta - P^{he}/P^h\right) \tag{3}$$

Which can be viewed as the imputed rent minus the expected change in house prices. Using this we define:

$$\mu = P^h v \tag{4}$$

Thereby allowing inversion to provide the following equation for house prices:

$$P^h = g\left(H/POP, y, v, D\right) \tag{5}$$

The empirical version of the inverted demand model used in this paper is in log level form and can be displayed as:

$$\ln P_t^h = \alpha_1 + \beta_1 \ln DEM_t + \gamma_1 \ln RDI_t + \lambda_1 \ln HS_t + \chi_1 r_t + \varepsilon_{1t} \tag{6}$$

Where *DEM* is population (25-44), *RDI* is real disposable income per capita, *HS* is the per capita housing stock and *r* is the real after-tax interest rate. As stated in the previous section, the real interest rate was used in preference to the user cost due to the incorporation of house price appreciation in the composition of the user cost. The model is initially estimated over the entire sample period of 1978 through 2003. The estimated fundamental value obtained is based on the fitted values. All of the variables, where appropriate, are modelled in real terms.

{Insert Table 1}

Table 1 details the reported coefficients from the static log regression. The estimation sees all variables take their anticipated sign and are all significant at conventional levels. Both the demographic and income variables are statistically significant and positively signed, while the per capita housing stock and real interest rate series provide significant negative coefficients with regard to prices. The adjusted R^2 of 0.9326 indicates that the model does capture most of the market movements during this period. The initial findings would appear to indicate a well specified model, which provides intuitive and significant coefficients, while capturing the majority of variation in house price dynamics. However, the diagnostics reported at the foot of Table 1 highlight considerable concerns over the use of such a model. Diagnostics are reported for serial correlation, heteroscedasticity, mis-specification and structural stability. In all cases diagnostic concerns are evident, with highly significant test statistics for each test. The results illustrate severe instability in the model and support some of the findings of previous studies of the Irish market in the suitability of such a modelling approach. While the Bacon et al. (1998) results generally satisfy diagnostic requirements, later studies have found, unsurprisingly given the price dynamics present in the market in the late nineties, increasing evidence of instability. However, with the exception of Stevenson (2003b), most of these

studies have not reported comprehensive statistics. Bacon & MacCabe (2000) solely report instability based on a Chow test, while Roche (1999, 2001), who uses the inverted demand framework to estimate fundamental value, does not report any diagnostic statistics on the estimations.

{Insert Table 2}

Two further concerns are evident with regard to the static approach used and reported in Table 1. The first issue relates to stationarity. The use of log levels in this model does not account for potential non-stationarity in the variables in question, nor does it examine cointegrating relationships between the variables concerned. This is the rationale behind the use of the error-correction framework disucussed in Section 4.2. The second concern is that by definition the model is based on the movements of the dependent variable throughout the sample period, including the periods of high growth observed since the mid-nineties. This estimation approach therefore does not allow for short-run dynamics to play a part in the determination of prices. This effectively means that a speculative element is therefore being used to model fundamental value. While this is a further justification behind the use of an error-correction model, we can also address this by estimating the inverted demand model on a rolling basis. This estimation starts in 1995, using data up until this point. The model is then re-estimated for each subsequent year with an additional year of data. Table 2 reports the results for the rolling estimation. Perhaps surprisingly, given the structural break results from the static estimastion, the coefficients are largely consistent across all of the time periods. The income and housing supply coefficients are of the anticipated sign and significant in each time period, while the population and interest rates variables are also significant for at least half of the periods. However, as with the results reported in Table 1 substantial diagnostic concerns are evident. In addition, it is also noticeable that the R-squared rises consistently across the rolling windows.

4.2: Error-Correction Framework

As noted in the previous section a key issue with the use of the inverted demand model is that the use of levels does raise concerns over stationarity. Roche (2001) argues that the use of a log-level model is appropriate when, as in that paper, a regime-switching model is being used to assess the speculative component. This is because in one state the non-fundamental price is explosive, while it is mean reverting in the second assumed state. Roche (2001) also cites Evans (1991) in arguing that cointegration tests tend to over-reject the presence of bubbles. However, given the concerns raised over both the diagnostics and the static nature of the

model, the inverted demand equation is re-estimated in an error-correction framework. This is a similar approach as used in papers such as Drake (1993), Ashworth & Parker (1997) and Kasparova & White (2001). An alternative to the simple error-correction approach adopted would be to model the market in a Vector Autoregressive (VAR) framework. However, a simple unrestricted VAR would encounter the problem of including the lagged values of the house price series, which as discussed previously, would bring into the estimation an element of expectations.

{Insert Tables 3 & 4}

As a precursor to the error-correction estimation unit root and cointegration tests are undertaken on the variables used. Table 3 reports the Augmented Dickey-Fuller unit root results for the five variables, while the Johansen cointegration test statistics are displayed in Table 4. The unit root results reveal that none of the variables are stationary in levels. The house price and interest rate series are both found to be I(1) and therefore stationary when first differenced. For the remaining three variables the series need to be differenced twice before significant ADF test statistics are reported. The lack of significant unit root results from the levels series further brings into question the use of levels in the inverted demand equation. The cointegration results are reported in Table 4. The results show that there is significant evidence of one cointegrating vector between the five variables examined. The λ_{max} statistic has as its null hypothesis that the number of cointegrating vectors is r against an alternative of r+1. The λ_{trace} statistic in comparison has an alternative that the number of cointegrating vectors is greater than r. It can be seen from Table 3 that both the λ_{max} and λ_{trace} statistics are significant with null hypothesis of r equals 0. These findings are similar to the cross-country study of Kasparova & White (2001), who found evidence of 1 cointegrating vector in each of the four countries examined.

{Insert Table 5}

The results from the short-run error-correction equation are reported in Table 5. In all cases the coefficients take their anticipated sign, and all but the housing stock variable are significant at conventional levels. As with the long-run log-level model both the demographic and income variables provide a significant positive impact upon house prices. Both the housing stock and interest rate variables are also of the expected negative sign. Finally, the error-correction term is significant and of the expected negative sign. The same diagnostic tests are conducted on the short-run model. Unlike the initial log-level estimation in the

majority of cases no diagnostic concerns are identified. The only significant finding is that the Chow Test, with a break at the end of 1989, is significant. The only slightly surprising finding is the low adjusted R^2, of only 0.1691. However, it should be emphasised that the aim of the paper is not to model the market as such, but rather to model fundamental prices. This is why lagged house prices were not included in the series. If the aim was to model and explain actual market movements then such variables would be included and in all likelihood result in a higher R^2.

4.3: Abraham & Hendershott Model

The third group of models used in the analysis are based on the approach proposed by Abraham & Hendershott (1996). The model is based on percentage price changes and assumes that real house price inflation can be modelled as follows:

$$p_t^* = \alpha_0 + \alpha_1 dem_t + \alpha_2 rdi_t + \alpha_3 hs_t + \alpha_4 r_t \tag{7}$$

Where p^* is the equilibrium real house price return, *dem* is the change in population aged 24-44, *rdi* is the growth in real disposable income per capita, *hs* is the change in housing stock and *r* is the change in real-after tax interest rates. The model assumes that actual house price movements can be modelled with the additional of an adjustment term. The adjustment term contains two components. The first is the lagged appreciation rate, which acts as a 'bubble builder'. The second component takes into account the fact that as speculative elements increase there is also an increased likelihood of the bubble collapsing. The 'bubble buster' is measured using the difference between actual house price levels and the estimated equilibrium value. The adjustment can be shows as follows:

$$\theta_t = \lambda_0 + \lambda_1 p_{t-1} + \lambda_2 \left(P_{t-1}^* - P_{t-1}\right) P_{t-1} + \Phi_t \tag{8}$$

By substituting Equation (8) into Equation (7) we obtain the final specification:

$$p_t = \beta_0 + \alpha_1 dem_t + \alpha_2 rdi_t + \alpha_3 hs_t + \alpha_4 r_t + \lambda_1 p_{t-1} + \lambda_2 \left(P_{t-1}^* - P_{t-1}\right) P_{t-1} + \Phi_t \tag{9}$$

As the equilibrium value is required to model itself equilibrium price appreciation, Abraham & Hendershott (1996) suggest initially estimating Equation (9) without the disequilibrium term. The predicted returns are used to obtain a first pass at the equilibrium values. This procedure is repeated until the coefficients stabilise. A total of 11 iterations were required

prior to the coefficients stabilising. As Hort (1998) and Bourassa et al. (2001) note, the Abraham & Hendershott (1996) model can be estimated in an error-correction framework, with the adjustment term equivalent to the error-correction term. The model is therefore estimated twice. Firstly, using the original approach of Abraham & Hendershott (1996) and secondly in an error-correction framework. The sole difference between this error-correction model and that estimated in Section 4.2 is that this specification does include lagged returns.

{Insert Table 6}

The results for the two approaches are reported in Table 6. As would be expected given the similarities in the specifications, the results are broadly in line with the initial ECM estimation. The income variable is positive and statistically significant in both estimations, while the interest rate variable and the error-correction/bubble burster terms are significant and as anticipated negatively signed. As with the original ECM specification, housing stock, while negative, is not significant. The main difference is that the population variable does not achieve significance, although it is correctly signed. The only major surprise in the coefficients reported is the negative sign for lagged price appreciation in both estimations. Given evidence in studies such as Case & Shiller (1989) concerning the autocorrelation present in housing the reporting of negative signs is against expectations. However, in neither method of estimation is the variable significant at conventional levels of significance. In relation to the diagnostic statistics reported, with the ECM estimation, the results are similar to the original error-correction specification; with only a significant diagnostic test statistic relating to the first Chow test. The OLS based approach to modelling the Abraham & Hendershott (1996) model does however provide further significant findings. In this case the second Chow test is also significant, as is the Ramsey RESET test and the Breusch-Godfrey test.

4.4: Levin & Wright Model

The final model used is that proposed by Levin & Wright (1997). The model is based on the premise that due to the supply constraints that housing operates under, changes in prices are primarily determined by demand shocks and that changes in demand conditions will determine expectations concerning future price appreciation. The authors base their model on the assumption that the fundamental valuation of a property can be defined as the sum of the price based on owner-occupation assuming zero capital gain, and the present value of expected capital gain.

$$P_t = P_t^z + G_t \tag{10}$$

Where:

$$G_t = G_t^* \frac{1}{(1+i)} \tag{11}$$

Where G_t^* is the expected capital gain in the following period and *i* is the one-period interest rate. The model is similar in some respects to other asset-based models of housing dynamics. The rationale behind the choice of the Levin & Wright (1997) model was purely based on the lack of quality reliable rental data, which underpins models such as Chan et al. (2001). In order to provide an empirically testable specification some assumption is required concerning the determination of the anticipated capital gain. In line with the idea of extrapolative expectations, Levin & Wright (1997) assume that historical movements determine the price movement in the following period. Therefore:

$$G_t^* = f(g_{t-1}) \tag{12}$$

Where:

$$g_{t-1} = \left[(P_{t-1} - P_{t-2}) \Big/ P_{t-2} \right] \tag{13}$$

The authors assume that the fundamental value based on zero capital gain is related to income and the one period interest rate, thereby allowing the following empirical specification:

$$P_t = \alpha + \beta_1 y_t + \beta_2 i_t + \beta_3 \left[g_{t-1} \Big/ (1+i_t) \right] + \varepsilon_t \tag{14}$$

Where *y* is income. The results are displayed in Table 7. The findings are broadly in line with expectations and given the findings already reported are not that surprising. Both the income and interest rate variables are of the expected sign and statistically significant. However, the capital appreciation variable is not significant. However, this in part may be explained given the lack of autocorrelation structure reported in the Abraham & Hendershott (1996) results. Given that the model is estimated in levels, the poor diagnostics are not surprising given the initial results reported for the standard inverted demand equation. All of the diagnostic results, bar the White heteroscedasticity tests, report significant test statistics.

{Insert Tables 7 & 8}

As with the inverted demand model rolling estimations are made for the Levin & Wright (1997) model. These results are displayed in Table 8 and are in many respects similar to those reported with regard to the rolling inverted demand model. As in that case the coefficients are generally stable across the different time periods, with income and interest rates being of the anticipated sign and significant at conventional levels in each period. As with the estimation over the entire time period only the appreciation variable fails to achieve significance. However, as with the inverted demand models, diagnostic concerns are reported in each time period.

5: Estimates of Fundamental and Non-Fundamental Value

This section of the empirical analysis reports on the estimated fundamental and non-fundamental values derived from the models estimated in Section 4. Initially the fundamental prices are examined, together with implied premiums/discounts that actual reported prices have other these estimates. The fundamental prices for the inverted demand and Levin & Wright models are simply based on the fitted values from the two models. For the three remaining models an additional assumption is required as the fitted values are not in levels, but rather reflect price changes. In order to estimate the equilibrium value it is necessary to specify a single period at which point the market is assumed to be in equilibrium. For the purposes of this study we use Quarter 1 1997 as the equilibrium point. The choice behind the use of a relatively late year was motivated by the fact that, especially in real terms, the market had been largely stationary for the previous twenty years. Market commentators would also agree that some element of the initial boom was catch up as the market was effectively undervalued in the early to mid-nineties.

{Insert Charts 3 & 4}
{Insert Tables 9 & 10}

In order to ease comparisons with the original raw data the estimated fundamental values for all of the models re-incorporate inflation to provide fundamental estimates in nominal terms. Table 9 and Chart 3 display the estimated fundamental values and actual average second-hand house prices. The premium/discount that actual prices have over the estimated fundamental values are reported in Table 10 and Chart 4. These figures are based on Quarter 4 of each year respectively. A number of issues come to light from examining the results presented. Broadly

all of the models follow a similar pattern in the estimated premium over fundamental since the mid nineties, however, differences are observable across the different methodological approaches. In terms of the similarities, all of the models show a premium developing in the late nineties, with the highest premium, and therefore hypothesised speculative component, being present in 2000. The only exceptions are the OLS version of the Abraham & Hendershott (1996) model and the rolling estimation of the inverted demand model and the Levin & Wright (1997) model. In the case of the Abraham & Hendershott (1996) model the highest premium is reported in 1999, however, the 2000 percentage premium is only 0.04% lower. For the two rolling models the highest premiums over fundamental are reported in 1998. All of the markets also see a drop in the reported premiums for 2001, similar to the findings of Stevenson (2003b). This is perhaps due to the market being driven by expectations, with prices leading economic fundamentals in the late nineties. Given the level of consumer confidence and general confidence in the economy and the housing market this hypothesis could explain the divergence between fundamental and actual prices during the late nineties.

The results for the inverted demand and Levin & Wright (1997) models do warrant further attention. While the estimation for both models showed considerable consistency across the rolling windows, there remain concerns over stationarity and cointegration. In addition, as discussed earlier in the paper, by definition, both models will effectively smooth the divergences from actual prices. If one examines Chart 3 it can be seen that the two static specifications report considerable discounts in the market during the mid nineties, with only relatively small premiums reported for the late nineties. The contrast between these findings and those of the ECM model, which allows for short-run dynamics and divergences from the long-run equilibrium, is in many cases substantial. To some degree, while the estimated premium for 2003 can be viewed as accurate, doubt does have to be cast on the previous findings. This is an important point given that most of the previous studies of the Irish market have adopted this standard inverted demand approach, including Roche (1999, 2001), in his assessment of speculative behaviour. This is addition to the concerns over diagnostics and stationarity discussed in Section 4. This issue is therefore a further reason behind the rolling estimation in Section 4. This provides a more effective and perhaps reliable estimate of fundamental value in any one period during the sample than the use of a single estimation. The estimated premiums for the two rolling specifications are are in line with those reported using the alternative methodologies.

One of the core hypotheses of this paper is that the rebound in prices in the final two years of the sample would see an increase in the speculative component, due to the relatively weaker

economic conditions at present in comparison to the late nineties. However, in only three cases is there a substantial increase in the premiums observed. For the static inverted demand model the reported premium rises to 15.09% for year-end 2003, from a figure of –1.43% in 2001. The corresponding figure for the rolling estimation in 2001 is 2.16%. The other model that sees an increase in the premium to a substantial degree is the error-correction specification of the Abraham & Hendershott (1996) model. However, in this case the premium for 2001 was still relatively high at 21.46%, rising to 29.22% at the end of the sample period. In of the remaining cases the premium over market fundamentals has largely stabilised at the levels seen in 2001. With the exception of the static inverted demand model in no case have current premiums reached levels approaching their peak in 1999 and 2000. This would imply that while the market has rebounded in 2002 and 2003, the price increases seen in these two years have not resulted in a significant shift in the pricing of the market relative to fundamentals. However, while recent price behaviour has not had the anticipated effect of an increase in the speculative component, the premiums reported are still substantial, with only the Levin & Wright (1997) model implying that the market is largely in equilibrium. This model has in most time periods been the most conservative model in terms of the premium present in the market, with its highest premium only being 13.39% in 2000 for the static specification, and 21.73% in 1998 in the dynamic version. The static versions premiums are below all of the highest premiums reported for the other four models, and in many cases substantially below. For example, the ECM model, the rolling inverted demand model and the two specifications of the Abraham & Hendershott (1996) model all resulted in estimated premiums in excess of 30% at their peak. With the exception of the Levin & Wright (1997) model, all of the other five models provide relatively consistent premiums for 2003. While the error-correction version of the Abraham & Hendershott (1996) specification is by a considerable margin the highest estimate for 2003 at 29.22%, the remaining four models are within a 4% band between 15% and 19%.

While the results across all five model specifications do indicate that a speculative component has been present in the market during the last ten years, it should also be noted that the majority of the increases in actual prices can be justified by fundamentals. If one examines the nominal prices displayed in Table 9, they illustrate that from the fourth quarter of 1995 to the corresponding period in 2003 actual average prices rose by 260%. Both the Levin & Wright (1997) and the error-correction model estimate increases in fundamental prices in excess of 200%. Indeed, even the log-level inverted demand equation estimates an increase of 162%. Therefore, although price increases have been considerable, the economic and demographic features discussed in Section 2, and incorporated into the different models, can be felt to explain the majority of the price increases in Irish house prices.

6: Conclusion:

This paper has provides updated empirical evidence on the speculative component present in the Irish residential market during the recent housing boom. The evidence obtained indicates that a substantial speculative premium was present in the market during the late nineties and while this did decline in 2001 most of the models used do indicate the continued presence of a substantial speculative element in the market. The paper also highlights methodological concerns over the use of some approaches in the modelling of fundamental value. Conventional models such as the inverted demand model can fail, if estimated in a static manner over the entire sample period, to fully capture short-run deviations from fundamental value.

References:

Abrahams, J. & Hendershott, P. (1996). Bubbles in Metropolitan Housing Markets, *Journal of Housing Research*, **7**, 191-208.

Ashworth, J. & Parker, S. (1997). Modelling Regional House Prices in the UK, *Scottish Journal of Political* Economy, 44, 225-246.

Bacon, P. & MacCabe, F. (1999). *The Housing Market: An Economic Review and Assessment*, The Stationery Office, Dublin.

Bacon, P. & MacCabe, F. (2000). *The Housing Market in Ireland: An Economic Evaluation of Trends and Prospects*, The Stationery Office, Dublin.

Bacon, P., MacCabe, F. & Murphy, A. (1998). *An Economic Assessment of Recent House Price Developments*, The Stationery Office, Dublin.

Ben-Shahar, D. (2004). *Behavioural Tenure Choice*, Paper presented at the 2004 Hong Kong-Singapore International Real Estate Research Symposium.

Berry, J., McGreal, S., Stevenson, S. & Young, J. (2001). Government Intervention and its Impact on the Housing Market in Greater Dublin*, Housing Studies,* **16**, 755-769.

Berry, J., McGreal, S., Stevenson, S., Webb, J. & Young, J. (2003). Estimation of Apartment Submarkets*, Journal of Real Estate Research,* **25**, 159-170.

Bourassa, S.C., Hendershott, P.H. & Murphy, J. (2001). Further Evidence on the Existence of Housing Market Bubbles, *Journal of Property Research*, **18**, 1-20.

Brereton, F. & Murphy, A. (2001). *Modelling Irish House Prices: A Review*, paper presented at the University College Dublin symposium on Housing Economics.

Brown, J., Song H. & McGillivray, A. (1997). Forecasting UK House Prices: A Time-Vary Coefficient Approach, *Economic Modelling*, **14**, 529-548.

Case, K.E. & Shiller, R.J. (1989). The Efficiency of the Market for Single Family Homes, *American Economic Review*, **79**, 125-137.

Chan, H.L., Lee, S.K. & Woo, K.Y. (2001). Detecting Rational Bubbles in the Residential Housing Markets of Hong Kong, *Economic Modelling*, **18**, 61-73.

Clapp, J. & Giaccotto, C. (1994). The Influence of Economic Variables on Local Price Dynamics, *Journal of Urban Economics*, **36**, 161-183.

Drake, L. (1993). Modelling House Prices using Cointegration: An Application of the Johansen Technique, *Applied Economics*, **25**, 1225-1228.

Evans, G. (1991). Pitfalls in Testing for Explosive Bubbles in Asset Prices, *American Economic Review*, **81**, 922-930.

Hall, S., Psaradakis, Z. & Sola, M. (1997). Switching Error-Correction Models of House Prices in the United Kingdom, *Economic* Modelling, 14, 517-527.

Holly, S. & Jones, N. (1997). House Prices since the 1940's: Cointegration, Demography and Asymmetries*, Economic Modelling,* **14**, 549-565.

Kasparova, D. & White, M. (2001). The Responsiveness of House Prices to Macroeconomic Forces: A Cross-Country Comparison, *European Journal of Housing Policy,* **1**, 385-416.

Kenny, G. (1999). Modelling the Demand and Supply Sides of the Housing Market: Evidence from Ireland*, Economic Modelling,* **16**, 389-409.

Kenny, G. (2003). Asymmetric Adjustment Costs and the Dynamics of Housing Supply*, Economic Modelling,* **20**, 1097-1111.

Levin, E.J. & Wright, R.E. (1997). Speculation in the Housing Market*, Urban Studies,* **34**, 1419-1437.

McQuinn, K. (2004). *A Model of the Irish Housing Sector*, Research Technical Paper, 1/RT/04, Central Bank and Financial Services Authority of Ireland.

Malpezzi, S. (1999). A Simple Error Correction Model of House Prices, *Journal of Housing Economics*, **8**, 27-62.

Meen, G. (2002). Time-Series Models of Housing: A Transatlantic Divide ?, *Journal of Housing Economics*, **11**, 1-23.

Muellbauer, J. & Murphy, A. (1997). Booms and Busts in the UK Housing Market, *The Economic Journal*, **107**, 1701-1727.

Pain, N. & Westaway, P. (1997). Modelling Structural Change in the UK Housing Market: A Comparison of Alternative House Price Models*, Economic Modelling,* **14**, 587-610.

Poterba, J. (1991). House Price Dynamics: The Role of Tax Policy and Demography, *Brookings Papers on Economic Activity*, **2**, 143-203.

Roche, M. (1999). Irish House Prices: Will the Roof Cave in ?, *The Economic and Social Review*, **30**, 343-362.

Roche, M. (2001). The Rise in House Prices in Dublin: Bubble, Fad or just Fundamentals, *Economic Modelling*, **18**, 281-295.

Stevenson, S. (2003a). *House Price Diffusion and Inter-Regional and Cross-Border House Price Dynamics*, working paper, Centre for Real Estate Research, University College Dublin.

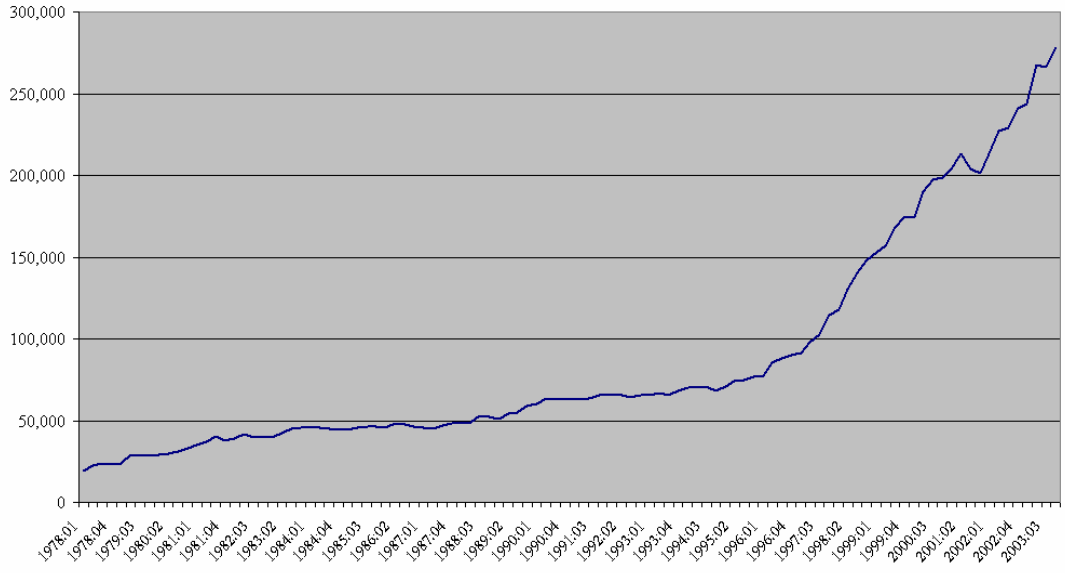
Stevenson, S. (2003b). *Economic, Demographic & Fiscal Influences on Housing Market Dynamics*, working paper, Centre for Real Estate Research, University College Dublin.

Stevenson, S. & Young, J. (2004). A Comparison of Residential Guide Prices and Auction Results, *Property Management*, **22**, 45-54.

Van Norden, S. (1996). Regime Switching as a Test for Exchange Rate Bubbles, *Journal of Applied Econometrics*, **11**, 219-251.

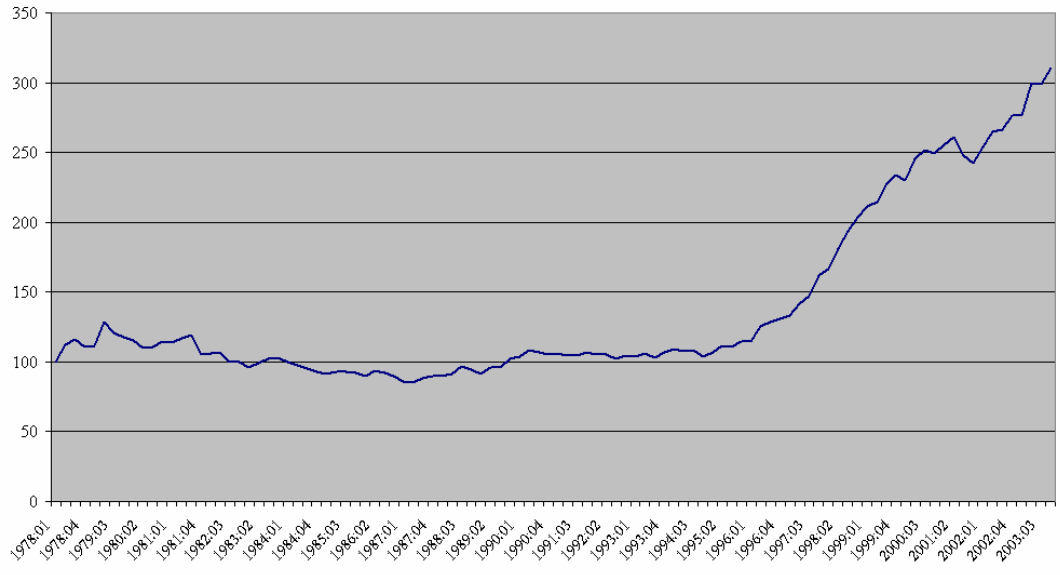
Tables & Charts:

Chart 1: Average Second-Hand Prices (€), 1978-2003



Notes: Chart 1 displays the average second-hand house price across Ireland as reported by the Department of the Environment, Heritage & Local Government.

Chart 2: Real Second Hand House Prices, 1978-2003



Notes: Chart 2 displays an index of the average second-hand house price in real terms for the period 1980 to 2003. The Consumer Price Index is used to deflate the house prices.

Table 1: Static Long-Run Inverted Demand Model

Variable	Test Statistics
Constant	-103.6480 {16.8216} (-6.1616***)
Population 25-44	4.9191 {1.0151} (4.8461***)
Real Disposable Income per Capita	3.2987 {0.1765} (18.6880***)
Per Capita Housing Stock	-10.9141 {1.5499} (-7.0418***)
After-Tax Interest Rates	-0.0614 {0.0333} (-1.8459*)
R-Squared	0.9326
Durbin-Watson	0.1582
Breusch-Godfrey Serial Correlation LM Test	281.2977***
ARCH LM Test	369.6417***
White Heteroscedasticity Test	8.1246***
Ramsey RESET Test	111.5561***
Chow Test (Break 1989)	40.1982***
Chow Test (Break 1995)	88.5004***

Notes: Table 1 details the coefficients for the static inverted demand models estimated over the entire sample period of 1978 through 2003. * indicates significance at 90%, ** at 95% and *** at 99%. { } represent standard errors and ( ) t-statistics.

Table 2: Rolling Inverted Demand Model Results

Variable	1995	1996	1997	1998	1999	2000	2001	2002
Constant	-13.0189	-24.1044	-40.7495	-66.8708	-86.8439	-98.2856	-104.3509	-106.7745
	{8.6051}	{9.4231}	{11.4109}	{14.9649}	{16.6110}	{17.5860}	{17.2329}	{16.8271}
	(-1.5129)	(-2.5580**)	(-3.5711***)	(-4.4685***)	(-5.2281***)	(-5.5889***)	(-6.0554***)	(-6.3454***)
Population 25-44	0.3226	0.8923	1.7477	3.0972	4.1228	4.6955	5.0133	5.1387
	{0.4969}	{0.5487}	{0.6700}	{0.8868}	{0.9921}	{1.0549}	{1.0385}	{1.0165}
	(0.6493)	(1.6264)	(2.6088**)	(3.4926***)	(4.1556***)	(4.4514***)	(4.8276***)	(5.0559***)
Real Disposable Income per Capita	1.3627	1.5906	1.9337	2.4536	2.8467	3.1021	3.2175	3.2667
	{0.1232}	{0.1288}	{0.14483}	{0.1834}	{0.1931}	{0.1963}	{0.1852}	{0.1767}
	(11.0611***)	(12.3508***)	(13.0429***)	(13.3780***)	(14.7426***)	(15.7990***)	(17.3755***)	(18.4979***)
Per Capita Housing Stock	-2.5736	-3.5943	-5.0891	-7.4761	-9.4317	-10.4813	-11.0107	-11.2195
	{0.7918}	{0.8672}	{1.0519}	{1.3809}	{1.5267}	{1.6160}	{1.5865}	{1.5509}
	(3.2502***)	(-4.14475***)	(4.8379***)	(-5.4138***)	(-6.1777***)	(6.4859***)	(-6.9402***)	(-7.2344***)
After-Tax Interest Rates	0.0292	0.0077	-0.0064	-0.0246	-0.0612	-0.0675	-0.0640	-0.0634
	{0.1546}	{0.0168}	{0.0209}	{0.0284}	{0.0315}	{0.0337}	{0.0336}	{0.0331}
	(1.8901*)	(0.4587)	(-0.3040)	(-0.8659)	(-1.9409*)	(-2.0040**)	(-1.9033*)	(-1.9166*)
R-Squared	0.7549	0.7514	0.7609	0.7791	0.8338	0.8693	0.8988	0.9195
Durbin-Watson	0.8724	0.6374	0.4069	0.2219	0.1634	0.1470	0.1536	0.1547
Breusch-Godfrey Serial Correlation LM Test	3.2073***	5.5121***	11.3234***	25.6504***	38.9260***	44.0276***	45.6716***	45.3467***
ARCH LM Test	3.2970***	5.2290***	7.2869***	28.0553***	20.8094***	18.2755***	18.7810***	21.8671***
White Heteroscedasticity Test	1.5738	2.3885**	6.8911***	14.5501***	18.7070***	7.8664***	7.6297***	7.7146***
Ramsey RESET Test	1.6976	0.2027	37.2129***	163.1741***	216.1304***	261.7903	151.9563***	107.0874***

Notes: Table 2 details the coefficients for the rolling inverted demand models estimated over the sample period of 1978 through 2003. * indicates significance at 90%, ** at 95% and *** at 99%. { } represent standard errors and ( ) t-statistics.

Table 3: Augmented Dickey-Fuller Unit Root Tests

	Levels	First Differences	Second Differences
Real House Prices	2.5196	4.5007*	-
Population 25-44	1.2122	2.2202	6.5386*
Real Disposable Income per Capita	2.2493	1.3271	8.3209*
Per Capita Housing Stock	1.2846	1.1047	4.1486*
After-Tax Interest Rates	0.6108	5.0917*	-

Notes: Table 3 reports the adf test results for the variables used in the analysis. The critical value for significance at 90% is 3.78. * indicates significance at this level.

Table 4: Johansen Cointegration Results

Null Hypothesis	λ_{max}	λ_{trace}	Max Critical Value (90%)	Trace Critical Value (90%)
R=0	37.7874	81.4941	30.4396	60.0614
R<=1	20.6098	34.1059	24.1592	40.1749
R<=2	13.0413	23.0968	17.7973	24.2760
R<=3	9.5086	10.0556	11.2248	12.3209
R<=4	0.5469	0.5469	4.1299	4.1299

Notes: Table 4 reports multivariate Johansen cointegration results, together with the appropriate critical values. The lag length in the Johansen VAR was determined by the Schwartz and Hanna-Quinn information criteria's. A lag length of 2 was thus specified and used.

Table 5: Short-Run Error-Correction Results

Variable	Test Statistics
Constant	-0.0139
	{0.0106}
	(-1.3130)
Population 25-44	3.5184
	{2.0973}
	(1.6776*)
Real Disposable Income per Capita	2.0950
	{0.4916}
	(4.2614***)
Per Capita Housing Stock	-1.8249
	{2.4524}
	(-0.7441)
After-Tax Interest Rates	-0.0478
	{0.0224}
	(-2.1339**)
Error Correction Term	-0.0767
	{0.0373}
	(-2.0540**)
R-Squared	0.1691
Durbin-Watson	2.0737
Breusch-Godfrey Serial Correlation LM Test	1.3348
ARCH LM Test	0.0012
White Heteroscedasticity Test	0.7181
Ramsey RESET Test	0.0620
Chow Test (Break 1989)	3.4663***
Chow Test (Break 1995)	0.7584

Notes: Table 5 details the coefficients for the error-correction specifications. * indicates significance at 90%, ** at 95% and *** at 99%. { } represent standard errors and ( ) t-statistics.

Table 6: Abraham & Hendershott Results

Variable	Recursive OLS	Error-Correction
Constant	-0.0236	-0.0131
	{0.0125}	{0.0105}
	(-1.8859*)	(-1.2509)
Population 25-44	3.3382	2.5631
	{2.2488}	{2.1679}
	(1.4844)	(1.1823)
Real Disposable Income per Capita	1.5547	2.0219
	{0.6064}	{0.5604}
	(2.5638**)	(3.6077***)
Per Capita Housing Stock	-0.3637	-0.6338
	{2.5507}	{2.5444}
	(-0.1426)	(-0.2491)
After-Tax Interest Rates	-0.0544	-0.0461
	{0.0224}	{0.0223}
	(-2.4298**)	(-2.0721**)
Lagged House Price Appreciation	-0.1177	-0.0731
	{0.1015}	{0.1017}
	(-1.1596)	(-0.7183)
Error Correction Term	-0.1138	-0.0746
	{0.0562}	{0.0370}
	(-2.0266**)	(-2.0146**)
R-Squared	0.1393	0.1396
Durbin-Watson	1.8338	1.9948
Breusch-Godfrey Serial Correlation LM Test	2.5433*	0.4203
ARCH LM Test	0.0065	0.1285
White Heteroscedasticity Test	0.7068	0.6137
Ramsey RESET Test	2.8789*	0.4178
Chow Test (Break 1989)	4.3054***	2.8682***
Chow Test (Break 1995)	2.4867**	1.1607

Notes: Table 6 details the coefficients for the two alternative specifications of the Abraham & Hendershott bubble model. * indicates significance at 90%, ** at 95% and *** at 99%. { } represent standard errors and ( ) t-statistics.

Table 7: Levin & Wright Results

Variable	Test Statistics
Constant	-9.5478
	{1.0114}
	(-9.4406***)
Income	2.3595
	{0.1074}
	(21.9757***)
Interest Rates	-0.0707
	{0.0292}
	(-2.4211**)
PV Capital Appreciation	0.2672
	{0.3683}
	(0.7254)
R-Squared	0.9625
Durbin-Watson	0.1209
Breusch-Godfrey Serial Correlation LM Test	170.7182***
ARCH LM Test	603.6360***
White Heteroscedasticity Test	1.7825
Ramsey RESET Test	12.1942***
Chow Test (Break 1989)	17,7512***
Chow Test (Break 1995)	6.5909***

Notes: Table 7 reports the results from the Levin & Wright specification. * indicates significance at 90%, ** at 95% and *** at 99%. { } represent standard errors and ( ) t-statistics.

Table 8: Rolling Levin & Wright Model Results

Variable	1995	1996	1997	1998	1999	2000	2001	2002
Constant	-3.7186	-3.7599	-4.6300	-6.2410	-7.1878	-8.4970	-9.3917	-9.5498
	{1.6301}	{1.5247}	{1.4169}	{1.3905}	{1.3570}	{1.2963}	{1.1645}	{1.0762}
	(-2.2812**)	(-2.4661**)	(-3.2675***)	(-4.4885***)	(-5.2967***)	(-6.5546***)	(-8.0650***)	(-8.8735***)
Income	1.7008	1.7056	1.8044	1.9857	2.0954	2.2425	2.3420	2.3596
	{0.1804}	{0.1679}	{0.1552}	{0.1517}	{0.1473}	{0.1400}	{0.1248}	{0.1148}
	(9.4274***)	(10.1611***)	(11.6283***)	(13.0886***)	(14.2237***)	(16.0185***)	(18.7603***)	(20.5605***)
Interest Rates	-0.1013	-0.1016	-0.0984	-0.0891	-0.0920	-0.0824	-0.0721	-0.0707
	{0.0309}	{0.0298}	{0.0295}	{0.0307}	{0.0311}	{0.0315}	{0.0308}	{0.0299}
	(-3.2799***)	(-3.4122***)	(-3.3344***)	(-2.8976***)	(-2.9543***)	(-2.6119**)	(-2.3430**)	(-2.3632**)
PV Capital Appreciation	-0.0034	0.0281	0.1361	0.5509	0.5355	0.4586	0.3144	0.2967
	{0.5006}	{0.4581}	{0.4464}	{0.4296}	{0.4332}	{0.4306}	{0.4059}	{0.3878}
	(-0.0068)	(0.0613)	(0.3048)	(1.2822)	(1.2363)	(1.0649)	(0.7746)	(0.7649)
R-Squared	0.7773	0.8207	0.8642	0.8915	0.9172	0.9330	0.9436	0.9543
Durbin-Watson	0.1300	0.1350	0.1384	0.1578	0.1468	0.1309	0.1149	0.1139
Breusch-Godfrey Serial Correlation LM Test	11.7402***	12.4670***	13.9562***	16.8839***	20.1145***	23.5106***	26.4641***	27.8680***
ARCH LM Test	3.0299***	3.3520***	2.8016***	5.0498***	6.2164***	7.2892***	10.0710***	12.2443***
White Heteroscedasticity Test	2.1291*	2.0450*	2.0482*	1.9887*	1.6233	1.4099	1.3544	1.5588
Ramsey RESET Test	3.5742*	2.1991	0.0562	3.9316*	10.5302***	19.7643***	23.2438***	18.5916***

Notes: Table 8 details the coefficients for the rolling Levin & Wright models estimated over the sample period of 1978 through 2003. * indicates significance at 90%, ** at 95% and *** at 99%. { } represent standard errors and ( ) t-statistics.

Table 9: Estimated Fundamental Nominal House Prices

Year	Actual	Static Inverted Demand Model	Rolling Inverted Demand Model	Error Correction Model	A&H Recursive OLS	A&H ECM	Static Levin & Wright	Rolling Levin & Wright
1995	77,100	92,107	73,817	77,661	87,728	78,257	90,126	80,390
1996	89,971	101,618	80,143	89,060	91,265	88,671	100,305	87,206
1997	114,354	115,700	92,092	102,901	96,765	100,977	113,686	97,720
1998	148,049	132,860	111,527	117,466	107,057	115,652	133,957	121,622
1999	174,541	160,703	143,192	137,604	124,195	128,658	166,120	155,742
2000	198,915	176,582	166,479	151,798	141,578	145,468	175,430	169,168
2001	201,613	204,548	197,345	173,165	167,360	165,993	197,758	195,838
2002	241,054	231,905	226,345	207,275	205,569	195,576	233,163	233,108
2003	277,818	241,387	241,387	233,631	239,690	214,994	279,421	279,421

Notes: Table 9 displays the estimated fundamental value of house prices based on the results of the long-run demand equation, the ECM short-run model and the Abraham & Hendershott and Levin & Wright models. For the error-correction and Abraham & Hendershott models Quarter 1 1997 is used as the base period in each case. The results are displayed in nominal terms.

Chart 3: Actual & Estimated Fundamental Nominal House Prices, 1995-2003

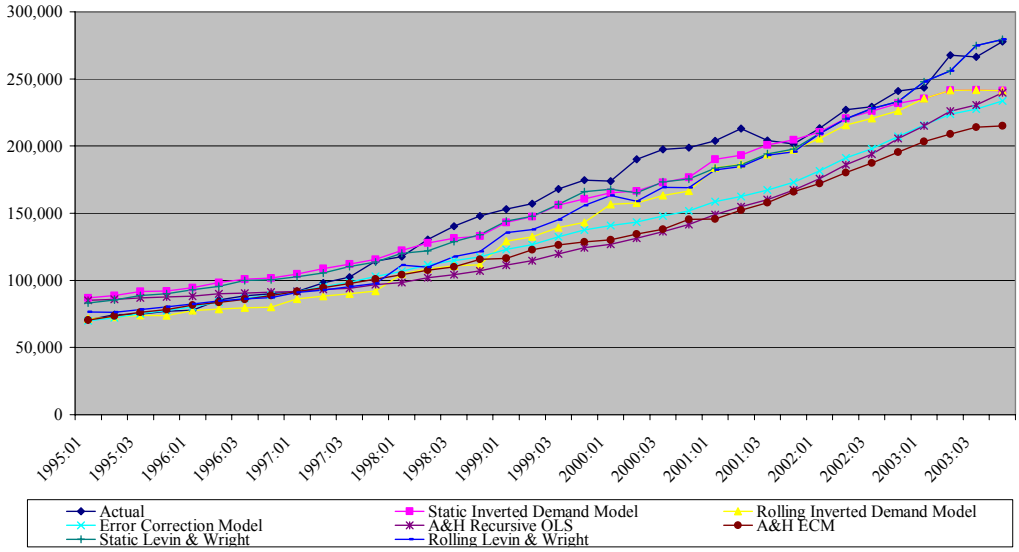
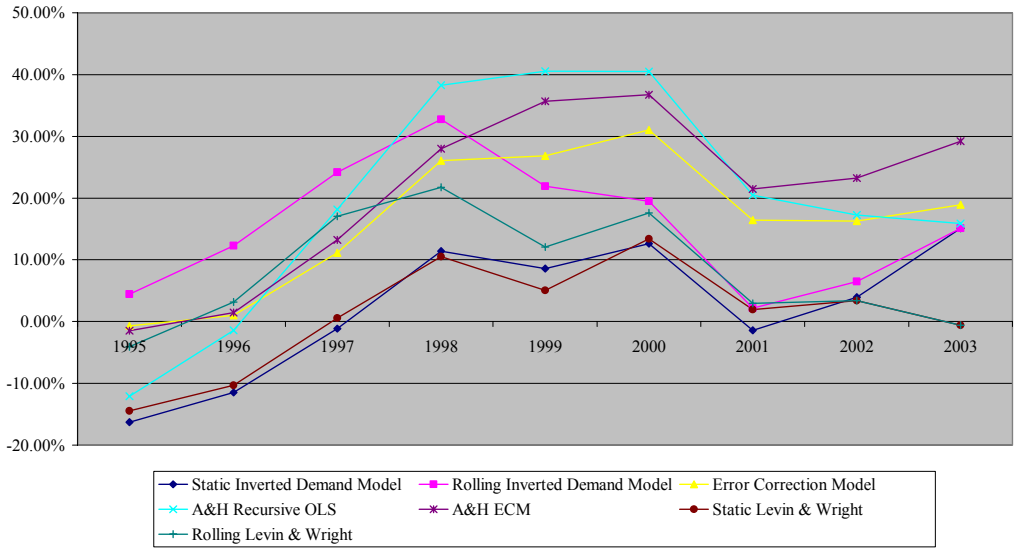


Table 10: Estimated Premium/Discount over Fundamental

Year	Static Inverted Demand Model	Rolling Inverted Demand Model	Error Correction Model	A&H Recursive OLS	A&H ECM	Static Levin & Wright	Rolling Levin & Wright
1995	-16.29%	4.45%	-0.72%	-12.12%	-1.48%	-14.45%	-4.09%
1996	-11.46%	12.26%	1.02%	-1.42%	1.47%	-10.30%	3.17%
1997	-1.16%	24.17%	11.13%	18.18%	13.25%	0.59%	17.02%
1998	11.43%	32.75%	26.04%	38.29%	28.01%	10.52%	21.73%
1999	8.61%	21.89%	26.84%	40.54%	35.66%	5.07%	12.07%
2000	12.65%	19.48%	31.04%	40.50%	36.74%	13.39%	17.58%
2001	-1.43%	2.16%	16.43%	20.47%	21.46%	1.95%	2.95%
2002	3.95%	6.50%	16.30%	17.26%	23.25%	3.38%	3.41%
2003	15.09%	15.09%	18.91%	15.91%	29.22%	-0.57%	-0.57%

Notes: Table 10 reports the estimated premiums/discounts of actual prices over the estimated fundamental values previously estimated. The percentage differences are based on the nominal figures contained in Table 9.

Chart 4: Percetage Premium/Discount over Fundamental



Endnotes:

[1] In addition to the studies mentioned below Berry et al. (2001) and Berry et al. (2003) examine issues in relation to the impact of government intervention. Stevenson & Young (2004) illustrate the speed of market movements in their comparative analysis of residential guide and sale prices.

[2] Stevenson (2003a) examines in greater depth the issue of house price diffusion in the Irish market. The results indicate that a large degree of diffusion takes place, particularly from Dublin to the other regions, in a manner that is similar and consistent with the UK ripple effect. Evidence of the importance of contiguous and non-contiguous areas is also evident beyond Dublin and the inter-relationship between provincial markets.

[3] Both the Irish Permanent Building Society, in association with the Economic & Social Research Institute, and the Centre for Real Estate Research at University College Dublin produce hedonic based indices. However, in both cases these indices are only available from the mid nineties. The Department of the Environment, Heritage & Local Government has started to provide a weighted average based measure of the market, however, at present historical estimates are not available.

[4] The full results using the user cost are available from the author on request.

[5] Meen (2002) provides a comprehensive review of alternative housing models, and in particular discusses the different approaches commonly used on both sides of the Atlantic.