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Abstract

In this paper recent developments in dynamic econometric methodology are used to explore the possibility of asset bubbles in the Northern Ireland housing market. This market is interesting as its house price trajectory is quite unlike any neighbouring market. In recent years it seems to have been influenced both by the general UK market and the Republic of Ireland's housing market. The dynamics of the market are explored through univariate analysis, using sequential unit root tests and fractional integration. The findings provide an indication of the principle developments in the market and could provide the basis for further causal analysis.

JEL CLassification: G2, C2, C5, E3

1 Introduction

The Northern Ireland housing market can be seen as unique in its behaviour. For most of the latter part of the last century house prices in Northern Ireland moved independently of both the other regions of the United Kingdom (UK) and the Republic of Ireland(RoI). In recent years it experienced volatile movements in house prices, with both rapid increases and decreases over a short period compared to other housing markets. This paper, using recent

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developments in the econometric analysis of time series, attempts to investigate these dynamics. This is done by placing the analysis in the context of asset bubbles.

Asset bubbles have been a topic of significant interest to both academics and policy makers for decades as a result of their reoccurring nature (Reinhart and Rogoff 2009, Kindleberger 1989).These episodes are often initiated by significant and persistent movements in asset prices and affect both developed and emerging economies (Ahamed 2009, Ferguson 2008) by impeding the efficient functioning of the financial sector and moreover the economy as a whole (Iacoviello 2005, Iacoviello and Neri 2010, Vargas-Silva 2008).

The aim of this paper is, through univariate analysis, to explore the dynamics of the Northern Ireland housing market and attempt to identify the structure of the house price trajectory from the early 1990s. In the next section the trajectory of house price movements is outlined and the theoretical and empirical literature on asset market bubbles discussed. The paper focuses primarily on the rational bubble literature. The methodology is described in section 3. Section 4 discusses the results and finally in section 5 conclusions are drawn.

2 Background

The historical development of house prices in Northern Ireland is quite different from the rest of the UK (McCord, McIlhatton, and McGreal 2011). During the late 1980s other regions of the UK experienced a sharp rise in house prices whereas in Northern Ireland house prices barely kept pace with the rate of inflation. It was in the late 1990s, after a long period of nearly static house prices, that Northern Ireland house prices began to rise in real terms like the rest of the UK. (Hicks and Baxter 2006). At the same time the Republic of Ireland was experiencing sharp rises in house prices (Gibb, Livington, Williams, Berry, Brown, and McGreal 2007). During the earlier years of this century the annual increase in house prices accelerated in Northern Ireland. This increase gathered pace until, by 2007, Northern Ireland was experiencing a faster growth in house prices than any other part of the UK

(Wilcox 2009). Northern Ireland house prices reached a peak in the third quarter of 2007 and since then have been declining more steeply than the rest of the UK and the Republic of Ireland. Figure 1 displays this movement in Northern Ireland house prices in real terms.

Many explanations have been given as to why these movements happen. At a macro level, liberal monetary policy coupled with the deregulation of the mortgage market is argued to have played a crucial role (Muellbauer and Murphy 1997, Baddeley 2005). The apparent cyclical relationship betweem mortgage lending and house price growth meant that the resulting gradual relaxation of credit standards increased demand for housing (see Hott 2011, for details). Evans (2004) and Gibb, Livington, Williams, Berry, Brown, and McGreal (2007) discuss the role played by the planning system in constraining supply and thereby further increasing house prices. At a more local level, Government policy advocating homeownership as a means to address the social and economic disparity that existed within the region has also been suggested as a key contributor to the house price growth in Northern Ireland (McCord, McGreal, Berry, Haran, and Davis 2011). There is also anecdotal evidence that external investment coming from the Republic of Ireland, following the saturation of their market, prolonged the increase in house prices (Adair, Berry, Haran, Lloyd, and McGreal 2009). Gibb, Livington, Williams, Berry, Brown, and McGreal (2007) argued at the height of the price rises that the almost continuous increase in house prices was seen as providing the opportunity for many to realise capital gain or secure a constant income from the rental market. They argued that this was creating a market characterised by speculative investment.

Most of the discussion has therefore been based on the argument that Northern Ireland may have experienced a house price bubble. However, it is still unclear when such a bubble, if it existed, started and how long it persisted. Graphs such as figure 1 are open to many interpretations. By considering what is meant by an asset bubble and how it might be measured, this paper attempts both to place the discussion of the Northern Ireland housing market in a more formal framework and provide insights into its development.

Asset bubbles

As O'Hara (2008, p.11) notes 'bubbles are both a topic of great importance and great controversy'. As yet there is no generally accepted definition of what an asset bubble is or how to identify and measure it. The lack of consensus over how best to define a bubble appears to emerge from different paradigms being adopted. For example, Kindleberger (1996) suggests that a bubble indicates an upward price movement over a prolonged period that subsequently explodes. Similarly, Brunnermeier (2007) suggests that a bubble describes a situation of dramatic price increases followed by a period of subsequent decline. In contrast, Garber (2000, p.7) contends that a bubble is merely 'a fuzzy word filled with import but lacking any solid operational definition'.

Gutierrez (2011) suggests that there are two divergent viewpoints within the literature on asset market bubbles. One view is that prices always reflect the market value of the asset and therefore bubbles do not exist. Proponents of this view (Garber 1990, Tirole 1982, Tirole 1985) argue that asset prices are always equal to the present discounted value of its future income. The other viewpoint that asset bubbles do exist can be divided into a number of different theoretical standpoints. Gutierrez (2011) highlights the following views: rational bubble behaviour (Shiller 1981), irrational bubbles (Vissing-Jorgensen 2004), intrinsic bubbles (Froot and Obstfeld 1991), fads (Shiller 1984) and informational bubbles (Grossman and Stiglitz 1980).

Considerable work has been undertaken to try and identify whether bubbles exist or not (Yin and Jin 2012). Most of this work has used the rational bubble literature as a starting point given that it is fairly easy to quantify. A rational bubble emerges when investors willingly pay more than the fundamental value to purchase an asset. They believe the price will continue to increase and thus the asset will significantly exceed its fundamental value in the future (Lansing 2010). In other words, as Stiglitz (1990, p.13) defined it 'If the reason that the price is high today is only because investors believe that the selling price is high tomorrow-when fundamental factors do not seem to justify such a price-then a bubble exists'.

The literature on the testing for asset bubbles reflects the developments in econometric analysis of time series (see Gurkaynak 2005, Flood and Hodrick 1990, for a review of traditional analysis). Using the rational asset bubble approach, early literature looked at the difference between the variance of the asset and the variance of the discounted future value of the asset. During a period of an asset bubble the difference between the two variables should be large. 'Simple' variance bounds test were used by Shiller (1981) and LeRoy (1981) and they found strong evidence of bubble behaviour in stock prices. Their analysis assumed that the series were stationary around a time trend (Marsh and Merton 1986) and had questionable small sample properties caused by not being able to correctly estimate the future value (Kleidon 1986). In West (1988) a variance bound test was introduced that addressed these issues. The work also found strong evidence of bubbles in stock market prices.

As the issue of stationarity became better understood, unit root and co-integration techniques were widely utilised (Campbell and Shiller 1987, Diba and Grossman 1988). In these tests the underlying assumption is that the price of the asset and its fundamental value are co-integrated and a bubble occurs when the co-integrated relationship breaks down. All these methods have been criticised due to their inherent limitations and their vulnerability to subjectivity ((Driffill and Sola 1998, Gurkaynak 2008, Evans 1991), which often led to ambiguous results. For example, Diba and Grossman (1988) and Taylor and Peel (1998) found that the S&P 500 stock market index did not contain a bubble, whilst others reported the existence of one (Froot and Obstfeld 1991).

More recent approaches to the identification of bubbles include techniques based on fractional integration (see, Cunado, Gil-Alana, and de Gracia 2005, Frammel and Kruse 2011, for details) and sequential unit roots (Phillips, Wu, and Yu 2011). In the first approach the return series is tested for non-stable fractional integration ($0.5 < d$). This is an implication of bubble behaviour in the levels series. In the second approach the levels series is tested for a mildly explosive root using a right-tailed unit root test. If it is assumed that the fundamental value series is stationary, the simple price series may be used in both approaches, though this is open to debate (Yin and Jin 2012, Phillips, Wu, and Yu 2011). This paper applies the technique of sequential unit roots to the Northern Ireland house price data to identify the parameters of any bubble. It also investigates the usefulness of recent tests (Smith 2005, Qu 2011) against spurious fractional integration in identifying and understanding bubbles.

3 Methodology and Data

In this paper the concept of a financial bubble is operationalised using Phillips and Yu's (2011) method of using forward recursive regressions coupled with sequential right sided unit root tests. This approach is based on the work of Phillips, Wu, and Yu (2011) and makes use of the fact that during a bubble the financial series (house prices) departs from the strict, efficient martingale behaviour of markets. If, as the Phillips and Yu (2011) test assumes, house prices deviate from standard unit root behaviour during the bubble by exhibiting mildly explosive behaviour; it follows that the returns series is likely to have long memory at least during the period of the bubble (Cunado, Gil-Alana, and de Gracia 2005). However, exploring long memory in a series during the time of a financial bubble is complicated by the possibility that non-linearities in the series can lead to spurious results. It is well known that the short memory process affected by regime changes or smoothly varying trends can exhibit what appears to be long memory behaviour. In an attempt to overcome these issues, this paper uses the recent tests of Smith (2005) and Qu (2011) to examine the possibility of long memory in house prices. In Frammel and Kruse (2011) the test proposed by Sibbertsen and Kruse (2009) is used to explore the possibility of a bubble using the assumption that the nature of the memory will be different before and after a bubble.

Firstly, the now standard I(0)/I(1) analysis is conducted using two unit root test: the Augmented Dickey Fuller (ADF) and the more powerful ADF-GLS test of Elliott, Rothenberg, and Stock (1996). These unit root tests are compared to the stationarity test of Kwiatkowski-Phillips-Schmidt-Shin

(KPSS). The bubble analysis of Phillips and Yu (2011) is then used to explore the likelihood of a bubble and its possible structure. The tests of Lobato and Velasco (2007), Smith (2005) and Qu (2011) are then used to further explore the possible long memory behaviour of the time series of house prices. As many of these methods are not yet standard procedures in time series analysis, each is explained in turn below.

The Phillips and Yu maxDF_r^t and DF_r^t tests

In Phillips and Yu (2011) the issue of dating the timeline of financial bubbles is explored. They modify a technique proposed by Phillips, Wu, and Yu (2011) and provide a methodology for identifying bubble behaviour with consistent dating of their origination and collapse. Whilst the Phillips and Yu's (2011) provides a methodology for testing for bubble migration, this paper uses only their tests for a single series.

The methodology is based on the analysis of the mildly explosive stochastic process developed in Phillips and Magadalinos (2007a) and Phillips and Magadalinos (2007b). The methodology is to recursively estimate:

$$X_t = \mu + \delta X_{t-1} + \epsilon_t, \quad \epsilon_t \sim iid(0, \sigma^2).$$

To test for an explosive root the critical values of the standard Dickey Fuller test are obtained for the right-tailed alternative hypothesis $H_1 : \delta > 1$ rather than the normal left-tailed test $H_1 : \delta < 1$. The regression in the first recursion uses $\tau_0 = \lfloor nr_0 \rfloor$ observations for some fraction r_0 of the total sample, where $\lfloor .. \rfloor$ denotes the integer part of the argument. Subsequent regression build on this original data using successive observations giving a sample of size $\tau = \lfloor nr \rfloor$ for $r_0 \leq r \leq 1$. The standard Dickey-Fuller t test can be written as:

$$DF_r^t := \left(\frac{\sum_{j=1}^{\tau} \tilde{X}_{j-1}^2}{\hat{\sigma}^2} \right)^2 (\hat{\delta}_\tau - 1)$$

where $\hat{\delta}_\tau$ is the least squares estimate of δ based on the dfirst τ observations,

$\hat{\sigma}^2$ is the corresponding estimates of σ^2 and $\tilde{X}^2_{j-1} = X_{j-1} - \tau^{-1}\sum_{j=1}^{\tau} X_{j-1}$.

To test if a bubble exists Phillips and Yu (2011) suggest the $maxDF_r^t$ test that compares the sup statistics $sup_r DF_r^t$ with the right tail critical values obtained from the limit distribution $sup_{r\in[r_0,1]} r \int_0^r \tilde{W} dW / (\int_0^r \tilde{W}^2)^{1/2}$. Using simmulation they obtain a 5% critical values a sample size of 100 of 1.5073.

To explore the timeline of the bubble they suggest that the start of the bubble can be identified by $\hat{\tau}_e = \lfloor n\hat{r}_e \rfloor$, where:

$$\hat{r}_e = \underset{s\geq r_0}{inf} s : DF_s^t > cv_{\beta_n}^{df}$$

$cv_{\beta_n}^{df}$ is the right sided $100\beta_n\%$ critical value of the limit distribution of DF_r^t statistic based on $\tau_s = \lfloor ns \rfloor$ observations and β_n is the size of the one-sided test. Similarly, assuming the existence of $\hat{r}_e$, they date the collapse of the bubble by $\hat{\tau}_f = \lfloor n\hat{r}_f \rfloor$ where:

$$\hat{r}_f = \underset{s\geq \hat{r}_e + \gamma ln(n)/n}{inf} s : DF_s^t < cv_{\beta_n}^{df}.$$

$gammaln(n)/n$ is used so that the duration of the bubble is nonnegligible. For practical implemenation they set the critical value sequence for $cv_{\beta_n}^{df}$ using an expansion rule, so $cv_{\beta_n}^{df} = -0.08 + ln(\lfloor nr \rfloor)/C$. The value of the constant C can be varied to make the test more or less conservative. In Phillips and Yu (2011) a value $C = 5$ is used.

The LV-Wald Test

The Lobato and Velasco Wald (LV-Wald) test is an efficient extension of the fractional Dickey Fuller(FADF) test suggested by Dolado, Gonzalo, and Mayoral (2002). This earlier work proposed testing for fractionality against the alternative of a unit root by constructing the t ratio test on ϕ_1 in the ordinary least squares regression

$$\Delta y_t = \phi_1 \Delta^{d_1} y_{t-1} + u_t \qquad (t+1, 2, .., T)$$

Lobato and Velasco (2007) argues that using $\Delta^{d_1} y_{t-1}$ as the regressor is inefficient and suggest using instead the ordinary least squares regression:

$$\Delta y_t = \phi_2 z_{t-1}(d_2) + u_t \qquad (t+1, 2, .., T) \tag{1}$$

where

$$z_{t-1}(d_2) = \frac{(\Delta^{d_{2-1}} - 1)}{(1 - d_2)} \Delta y_t$$

Assuming $d_2 > 0.5$ they suggest using a simple left sided t-test to test the significance of ϕ_2 denoted by t_ϕ.

Smith's *modified-GPH* test

In Smith (2005) the properties of d, estimated (incorrectly) from a fairly general Mean-plus-Noise (MN) model, are considered. The general MN model has the form:

$$y_t = \mu_t + \epsilon_t \quad t = 1, 2, ..., T \tag{2}$$

and

$$\mu_t = (1 - p)\mu_{t-1} + \sqrt{p}\eta_t \qquad 0 < p < 1, \tag{3}$$

where ϵ_t and η_t are short-memory random variables each with zero mean and finite non-zero variance, ϵ_t and η_s are independent of each other for all t and s. The parameter p determines the persistence of the level component μ_t. This MN specification encompasses models such as Markov switching and stationary random level shift.

The *GPH* estimate of d for the MN model (2) and (3), say $\hat{d}_m$, is consistent under standard Gaussian assumptions but, as Smith (2005) shows, is biased upwards. By exploring the nature of this bias, Smith (2005) derives a modified version of the *GPH* that has a smaller bias. The modification is essentially the addition of an another term to the *GPH* regression. If $\hat{f}_j$, $j = 1, 2, \ldots, m$, is the periodogram, the modified regression is:

$$\log \hat{f}_j = \alpha + dX_j + \beta Z_{kj} + \hat{u}_j, \tag{4}$$

where X_j is the standard GPH term:

$$X_j = -\log(2 - 2cos(\omega_j)) \;\; \omega_j = \pi j/T$$

and Z_{kj} is the additional term:

$$Z_{kj} = -\log\left((kj)^2/T^2 + \omega_j^2\right),$$

where k is a nuisance parameter, which Smith (2005) suggests has a value between 1 and 5. Smith (2005) also shows that in many circumstances a value of $k = 3$ is optimal.

The *modified-GPH* estimator, $\hat{d}_m^k$, can be used to investigate whether the apparent fractional nature of a series is really due to mean shift. If $\hat{d}_m^k < \hat{d}_m$, then it is possible that the series contains a mean shift. If $\hat{d}_m^k > \hat{d}_m$, then it is unlikely that the evidence for fractional behaviour is due to mean shifts. Importantly, Smith (2005) points out that $\hat{d}_m^k$ should not be viewed as an estimate of the 'true' value of d as this requires non-trivial modelling.

A major issue with estimating *GPH* is choosing the number of frequencies m. Increasing the frequencies normally leads to smaller root mean square error but larger bias (Hurvich, Deo, and Brodsky 1999). Smith (2005) uses the rule of thumb, fixed value of $m = T^{1/2}$, suggested in Geweke and Porter-Hudak (1983) and the 'Plugin', root mean square minimizing value suggested by Hurvich and Deo (1999).

Qu's local Whittle-based test

Qu (2011) uses the properties of the local Whittle estimator of d, say $\hat{d}_w$, obtained by minimising the concentrated, in G, Whittle likelihood function $R(d) = logG(d) - 2m^{-1}d\sum_{j=1}^{m} log\lambda_j$ with repect to d to test whether the series has long memory or a break. In the function $R(d)$, λ is the frequency, $G(d) = m^{-1}\sum_{j=1}^{m}\lambda_j^{2d}I_j$, m is some integer that is small relative to n and $I_j = I_x(\lambda_j)$ the periodogram of x_t evaluated at frequency λ_j. In particular he notes that the quantity $m^{-1/2}\sum_{j=1}^{[mr]}\upsilon_j(I_j\lambda_j^{2d_0}/G_0) - 1$ derived by differentiating $R(d)$ with respect to d where [..] means the 'integer part of', $r \in [\epsilon, 1]$, where

ϵ is a small trimming parameter, and G_0 is the true value of G; when treated as a process in r satisfies a functional central limit theorem and is of $O_p(1)$ under the null hypothesis of long memory in the series x_t. Whereas, if the series x_t is short memory and affected by either regime change or a trend, the quantity diverges. Thus Qu suggests the following test statistic:

$$W = \sup_{r\in[\epsilon,1]} \left(\sum_{j=1}^{m} v_j^2\right) \left|\sum_{j=1}^{[mr]} v_j \left(\frac{I_j}{G(\hat{d}_w \lambda_j^{-2\hat{d}_w}} - 1\right)\right| \tag{5}$$

Using monte-carlo methods Qu derives 5% critical values of 1.252 when $\epsilon = 0.02$ and 1.155 when $\epsilon = 0.05$

The Data

The data utilised in the paper was sourced from the University of Ulster House Price Index (UUHPI), a survey which analyses the performance of NI house prices quarterly, based on a significant and representative sample size of open market transactions within the region. The data range covers the period 1990 Q1 to 2011 Q3. The real house price was computed as the nominal house price divided by the CPI. The issue of finding a series to represent the fundamental value of houses in Northern Ireland was explored, no readily available series for average rent was obtainable. In addition, whether the concept of 'average rent' is a safe a proxy for fundamental value given the distortions caused by a large 'social housing sector' in Northern Ireland is debatable. Thus, for this preliminary study the (logged) prices series was used. This means that the assumption being made is that the fundamental value is constant for the analysis period.

4 Results and discussion

Table 1 gives the results of the basic stationarity analysis of the series. From this it can be seen that the house price series appears to be I(1) and the returns I(0). This is in line with the finding of Diba and Grossman (1988) and would suggest that no bubble exists. This is because if prices were 'explosive' one would expect the returns series to be non-stationary. Despite using the more powerful $ADF-GLS$ test Evans's (1991) criticisms of this simple analysis may still be valid and the results fit with his observation that 'periodically collapsing bubbles are not detectable by using standard tests' Evans (1991, p.927).

The results of the Phillips and Yu's (2011) analysis is given in table 2 and figure 2. These suggest that there was a short but intense house price bubble between 2005 Q3 and 2009 Q1 reaching a peak in 2007 Q2. The trajectory of the t-statistic also suggests that there was perhaps a minor bubble at the turn of the century. These results need to be carefully interpreted. In particular the apparent bubbles could be due to the 'fundamental values' not being constant, as assumed. Whilst this might be the reason for the earlier bubble, it is unlikely to explain fully the more major result. However, as Phillips, Shi, and Yu (2012) shows the power of the $t-statistic$ test is less if there are multiple bubbles. Thus, it would seem safe to assume that the 2005-2009 bubble did exist.

Table 3 gives the *gph* $\hat{d}_m$ and local-Whittle $\hat{d}_w$ estimates of the fractional differencing parameter d. As expected both the $FADF$ and $LV-Wald$ tests fail to accept the null hypothesis that the series are $I(1)$ rather than $I(d)$. For the full period only the local-Whittle estimate of d is greater than 0.5, which is needed to support the hypothesis of a bubble during the period. This could be due to the period under consideration being too long. For the period 2002Q1 to 2011Q3 both of the *gph* estimates support the hypothesis of a bubble. The local-Whittle estimate is just slightly less than 0.5. For the earlier period only the 'plugin' *gph* estimate is greater than 0.5. The local-Whittle estimate is suggesting 'negative stable memory'.

Whether these fractional results are spurious or not is explored in tables 4 and 5. Table 4 gives the results of the modified gph analysis of Smith, again for the full period and also for the sub-period 2002Q1-2011Q3 and 1990Q1 - 2002Q1. For the full period the plugin analysis supports the hypothesis that the series contains a mean-shift whereas the fixed analysis does not. For the sub-period 2002Q1 - 2011Q3 the results are reversed. Finally for the period

1990Q1 - 2002Q1 there is no evidence to support the mean shift hypothesis. It is difficult to interpret these results as the choice of m the number of frequencies used seen to highly influence teh results obtained. In table 5 the results for the local-Whiitle test for full period are not really applicable as $\hat{(d)}_w > 0.5$ and a basic assumption of the test is that $d \in (-0.5, 0.5)$. With this in mind the table suggests that the only period where the local-Whittle estimate of d could be spurious is the period 1990Q1 - 2002Q1. Thus the fractional analysis through the obtaining on non-stationary estimates of $\hat{(d)}_w$ or $\hat{(d)}_m$ seems to support the idea of a bubble, though the tests are unclear as t whether the estiumates obtained are really due to long memory or to some other non-linearity in the series .

5 Conclusions

In this paper a preliminary econometric analysis of the dynamics of the Northern Ireland housing market has been presented. The results are interesting. They show the limitations of traditional $I(1)/I(0)$ analysis and suggest that both sequential unit root tests and fractional analysis could provide useful tools for further analysis. The sequential unit root tests seem to provide a method of simple analysis whilst the fractional analysis requires careful interpretation.

The paper has made the strong assumption that the real fundamental value of houses is stationary. The question remains as to whether this assumption is safe and if not, what series should be utilised as a proxy for the concept?

It would be easy at this stage to attempt to provide explanations for the behaviour discovered. For example, the apparent minor bubble at the turn of the century might be explained by the pushing out of first time buyers by rising prices (the number of mortgages to first-time buyers peaked in 2001). However, it might also be explained by the changes in the macro economic environment brought about by the availability of cheap money in the island of Ireland associated with the introduction of the euro. Exploring such issues is a major research exercise and beyond the scope of this paper. However, the paper provides the basis for such analysis.

References

Adair, A., J. Berry, M. Haran, G. Lloyd, and S. McGreal (2009): "The Global Financial Crisis: Impact on Property Markets in the UK and Ireland," *Report by the University of Ulster Real Estate Initiative Research Team*, 1, 1–66.

Ahamed, L. (2009): *The Bankers Who Broke the World*. Penguin Press, New York.

Baddeley, M. (2005): "Housing bubbles, herds and frenzies: evidence from British housing markets," *CEPP Policy Brief No. 02/05, Cambridge Centre for Economic and Public Policy,Cambridge, May.*, pp. 1–32.

Brunnermeier, M. K. (2007): "Bubbles. in L. Blume and S. Durlaug (eds)," The New Palgrave Dictionary of Economics. Oxford: Oxford University Press.

Campbell, J., and R. Shiller (1987): "Co-Integration and Tests of Present Value Models," *Journal of Political Economy*, 95, 1062–1088.

Cunado, J., L. Gil-Alana, and F. P. de Gracia (2005): "A test for rational bubbles in the NASDAQ stock index: A fractionally integrated approach," *Journal of Banking & Finance*, 29(10), 2633–2654.

Diba, B., and H. Grossman (1988): "Explosive rational bubbles in stock prices?," *The American Economic Review*, 78, 520–530.

Dolado, J. J., J. Gonzalo, and L. Mayoral (2002): "A fractional Dickey-Fuller test for unit roots," *Econometrica*, 70, 1963–2006.

Driffill, J., and M. Sola (1998): "Intrinsic Bubbles and Regime-Switching," *Journal of Monetary Economics*, 42, 351–385.

ELLIOTT, G., T. J. ROTHENBERG, AND J. H. STOCK (1996): "Efficient Tests for an Autoregressive Unit Root," *Econometrica*, 64(4), 813–36.

EVANS, A. (2004): *Economics, Real Estate and the Supply of Land.* Blackwell Science: Oxford.

EVANS, G. (1991): "Pitfalls in testing for explosive bubbles in asset prices," *The American Economic Review*, 81, 922–930.

FERGUSON, N. (2008): *The Ascent of Money.* Penguin Press, New York.

FLOOD, R. P., AND R. J. HODRICK (1990): "On Testing for Speculative Bubbles," *Journal of Economic Perspectives*, 4(2), 85–101.

FRAMMEL, M., AND R. KRUSE (2011): "Testing for a rational bubble under long memory," *Quantitative Finance*, forthcoming.

FROOT, K., AND M. OBSTFELD (1991): "Intrinsic bubbles: the case of stock price," *The American Economic Review*, 81, 1189–1214.

GARBER, P. M. (1990): "Famous First Bubbles," *Journal of Economic Perspectives*, 4(2), 35–54.

GARBER, P. M. (2000): *Famous First Bubbles.* MA: MIT Press, Cambridge.

GEWEKE, J., AND S. PORTER-HUDAK (1983): "The estimation and application of long-memory time series models," *Journal of Time Series Analysis*, 4, 221–237.

GIBB, K., M. LIVINGTON, V. WILLIAMS, J. BERRY, L. BROWN, AND S. MCGREAL (2007): "The Northern Ireland Housing Market: Drivers and Policies," *Final Report to the NIHE.*, 1, 1–132.

GROSSMAN, S., AND J. STIGLITZ (1980): "On the impossibility of informationally efficient markets," *The American Economic Review*, 70, 393–408.

GURKAYNAK, R. (2005): "Econometric tests of asset price bubbles: taking stock," *Finance and Economics Discussion Series, No. 2005-04, Board of Governors of the Federal Reserve System.*

Gurkaynak, R. (2008): "Econometric tests of asset price bubbles: taking stock," *Journal of Economic Surveys*, 22, 166–186.

Gutierrez, L. (2011): "Bootstrapping asset price bubbles," *Economic Modelling*, 28, 2488–2493.

Hicks, F., and L. Baxter (2006): "Northern Ireland Housing and Mortgage Market Developments," *Housing Finance*, 8.

Hott, C. (2011): "Lending Behaviour and real estate prices," *Journal of Banking and Finance*, 35, 2429–2442.

Hurvich, C., and R. Deo (1999): "Plug-in selection of the number of frequencies in regression estimates ofthe memory parameter of a long-memory time series," *Journal of Time Series Analysis*, 20, 331–341.

Hurvich, C., R. Deo, and J. Brodsky (1999): "The mean square error of Gweke and Porter-Hudak's estimator ofthe memory parameter of a long-memory time series," *Journal of Time Series Analysis*, 19, 19–46.

Iacoviello, M. (2005): "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle," *American Economic Review*, 95(3), 739–764.

Iacoviello, M., and S. Neri (2010): "Housing Market Spillovers: Evidence from an Estimated DSGE Model," *American Economic Journal: Macroeconomics*, 2(2), 125–64.

Kindleberger, C. (1989): *Manias, panics, and crashes: a history of financial crises*. Basic Books.

Kindleberger, C. P. (1996): *Manias, Panics and Crashes: A History of Financial Crises, 3rd ed.* John Wiley & Sons, New York.

Kleidon, A. W. (1986): "Variance Bounds Tests and Stock Price Valuation Models," *Journal of Political Economy*, 94, 953–1001.

Lansing, K. (2010): "Rational and Near Rational Bubbles without Drift," *The Economic Journal*, 120, 1149–1174.

LeRoy, S.F.and Porter, R. (1981): "The present-value relation: tests based on implied variance bounds," *Econometrica*, 49, 555–577.

Lobato, I. N., and C. Velasco (2007): "Efficient Wald Tests for Fractional Unit Roots," *Econometrica*, 75(2), 575–589.

MacKinnon, J. G. (1996): "Numerical Distribution Functions for Unit Root and Cointegration Tests," *Journal of Applied Econometrics*, 11(6), 601–618.

Marsh, T. A., and R. C. Merton (1986): "Dividend Variability and Variance Bounds Tests for the Rationality ofStock Market Prices," *American Economic Review*, 76(3), 483–98.

McCord, M., S. McGreal, J. Berry, M. Haran, and P. Davis (2011): "The implications of mortgage finance on housing market affordability," *International Journal of Housing Markets and Analysis*, 4, 394–417.

McCord, M., D. McIlhatton, and S. McGreal (2011): "The Northern Ireland Housing Market and Interconnections with the UK and Irish Housing Markets," *Housing Finance International*, 26,1, 28–34.

Muellbauer, J., and A. Murphy (1997): "Booms and busts in the UK housing market," *Economic Journal*, 107(445), 1701–1727.

O'Hara, M. (2008): "Bubbles: Some Perspectives (and Loose Talk) from History," *Review of Financial Studies*, 21(1), 11–17.

Phillips, P. C., and T. Magadalinos (2007a): "Limit Theory for Moderate Deviations from a Unit Root," *Journal of Econometrics*, 136(2), 115–130.

——— (2007b): "Limit Theory for Moderate Deviations from a Unit Root under Weak Dependence," in *The Refinement of Econometric Estimation and Test Procedures: Finite Sample and Asymptotic Analysis*, ed.

by G. D. A. Phillips, and E. Tzavalis, pp. 123–162. Cambridge University Press, Cambridge.

Phillips, P. C., S.-P. Shi, and J. Yu (2012): "Testing for Multiple Bubbles," Cowles Foundation Discussion Papers 1843, Cowles Foundation for Research in Economics, Yale University.

Phillips, P. C. B., Y. Wu, and J. Yu (2011): "Explosive Behavior in the 1990s NASDAQ: Whe did exuberance escalate asset values?," *International Economic Review*, 52(1), 201–226.

Phillips, P. C. B., and J. Yu (2011): "Dating the Timeline of Financial Bubbles during the Subprime Crisis," *Quantitative Economics*, 2(3), 455–491.

Qu, Z. (2011): "A Test Against Spurious Long Memory," *Journal of Business & Economic Statistics*, 29(3), 423–438.

Reinhart, C. M., and K. S. Rogoff (2009): "The Aftermath of Financial Crises," *American Economic Review*, 99(2), 466–72.

Shiller, R. (1981): "Do stock prices move too much to be justified by subsequent changes in dividends?," *The American Economic Review*, 71, 421–436.

——— (1984): "Stock prices and social dynamics," *Brookings Papers on Economic Activity*, 2, 457–498.

Sibbertsen, P., and R. Kruse (2009): "Testing for a break in persistence under long-range dependencies," *Journal of Time Series Analysis*, 30(3), 263–285.

Smith, A. (2005): "Level shifts and the illusion of long memory in economic time series," *Journal of Business & Economic Statistics*, 23, 321–335.

Stiglitz, J. (1990): "Symposium on bubbles," *Journal of Economic Perspective*, 4, 13–18.

Taylor, M. P., and D. A. Peel (1998): "Periodically collapsing stock price bubbles," *Economics Letters*, 61, 221–228.

Tirole, J. (1982): "On the possibility of speculation under rational expectations," *Econometrica*, 50, 1163–1181.

Tirole, J. (1985): "Asset bubbles and overlapping generations," *Econometrica*, 53, 1499–1528.

Vargas-Silva, C. (2008): "Monetary policy and the US housing market: A VAR analysis imposing sign restrictions," *Journal of Macroeconomics*, 30(3), 977–990.

Vissing-Jorgensen, A. (2004): "Perspectives on behavioral finance: does irrationalityŠŠ disappear with wealth? Evidence from expectations and actions," *in (M. Gertler and K. Rogoff, eds), NBER Macroeconomics Annual 2003,Cambridge, MA: MIT Press.*, pp. 139–194.

West, K. (1988): "Dividend innovations and stock price volatility," *Econometrica*, 56, 37–61.

Wilcox, S. (2009): "UK Housing Review," CIH & BSA: Coventry London.

Yin, M., and L. Jin (2012): "Detecting Bubbles in the Hong Kong Residential Property Market: An Explosive Pattern Approach," *HKIMR Working Paper No.01*, pp. 1–14.

Table 1: Basic $I(1)/I(0)$ analysis

Series	$\underset{(Prob.^{(1)})}{ADF}$	$KPSS^{(2)}$	$\underset{Prob.^{(1)})}{ADF-GLS^{(1)}}$
Prices	$\underset{(0.56)}{-1.45}$	2.17	$\underset{(0.69)}{0.02}$
Returns	$\underset{(0.01)}{-3.50}$	0.24	$\underset{(0.01)}{-2.50}$

1: Probabilities derived from MacKinnon (1996) unless otherwise noted
2: Null of stationarity 5% critical value 0.466

Table 2: Testing the presence of bubbles and date stamping

Series	$\max DF_r^t$	$\hat{\tau}_e(\hat{\tau}_0)$	$\hat{\tau}_f(\hat{\tau}_0)$
Prices	$\underset{(2007Q2)}{2.66}$	2005Q3	2009Q1

Table 3: Fractional Analysis

Method	J	$\underset{(s.e.)}{d}$	$FADF$	$LV-Wald$
			Full period	
gph	Plugin	0.35 (0.36)	-5.2	-6.5
gph	Fixed	0.28 (0.3)	-5.2	-6.6
Whittle	Fixed	0.55	-5.6	-6.4
			2002Q1 - 2011Q3	
gph	Plugin	0.56 (1.3)	-2.5	-2.9
gph	Fixed	0.73 (0.44)	-2.5	-2.9
Whittle	Fixed	0.47	-2.4	-2.7
			1990Q1 - 2002Q1	
gph	Plugin	0.61 (0.3)	-7.4	-7
gph	Fixed	0.32 (0.39)	-7.4	-7.8
Whittle	Fixed	-0.20	-3.1	-7.2

Table 4: Modified GPH

J	GPH $(s.e.)$	value of k: 1	2	3	4	5
			Full Period			
Plugin	0.35 (0.38)	−0.13 (3)	−0.036 (1.3)	−0.26 (0.89)	−0.073 (0.69)	0.027 (0.58)
Fixed	0.28 (0.32)	0.46 (2.4)	0.43 (1.3)	0.43 (0.98)	0.43 (0.85)	0.43 (0.79)
			2002Q1 - 2011Q3			
Plugin	0.56 (1.3)	−2.4 (71)	−0.36 (23)	2.9 (7.9)	2.1 (5.4)	0.74 (3.3)
Fixed	0.73 (0.44)	−2.2 (5.1)	−0.67 (2.3)	−0.36 (1.7)	−0.24 (1.4)	−0.18 (1.3)
			1990Q1 - 2002Q1			
Plugin	0.61 (0.3)	3.5 (1.4)	2.1 (0.75)	1.1 (0.56)	0.65 (0.45)	0.63 (0.39)
Fixed	0.32 (0.39)	5.2 (3.8)	2.8 (1.8)	2.2 (1.3)	2 (1.1)	1.9 (1)

Table 5: Qu's local Whittle test

$\hat{d}_w$	$\epsilon =$ 0.02	0.05	0.10
		Full period	
0.55	0.45	0.45	0.45
		2002Q1-2011Q3	
0.47	0.54	0.54	0.54
		1990Q1-2002Q1	
-0.20	1.33	1.33	1.33
		5% critical value	
	1.252	1.155	*

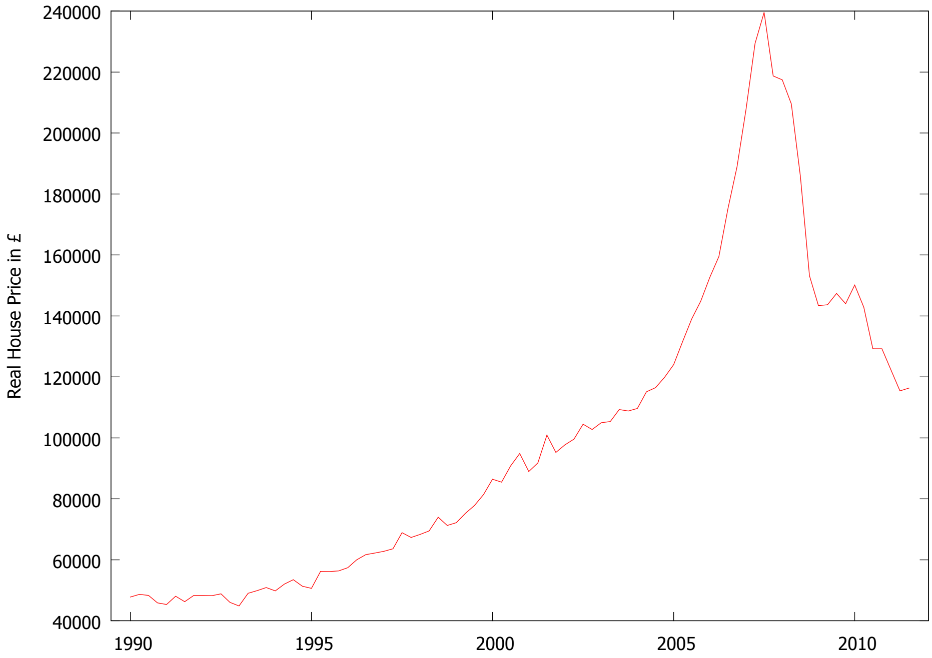

Figure 1: Real House Prices Northern Ireland

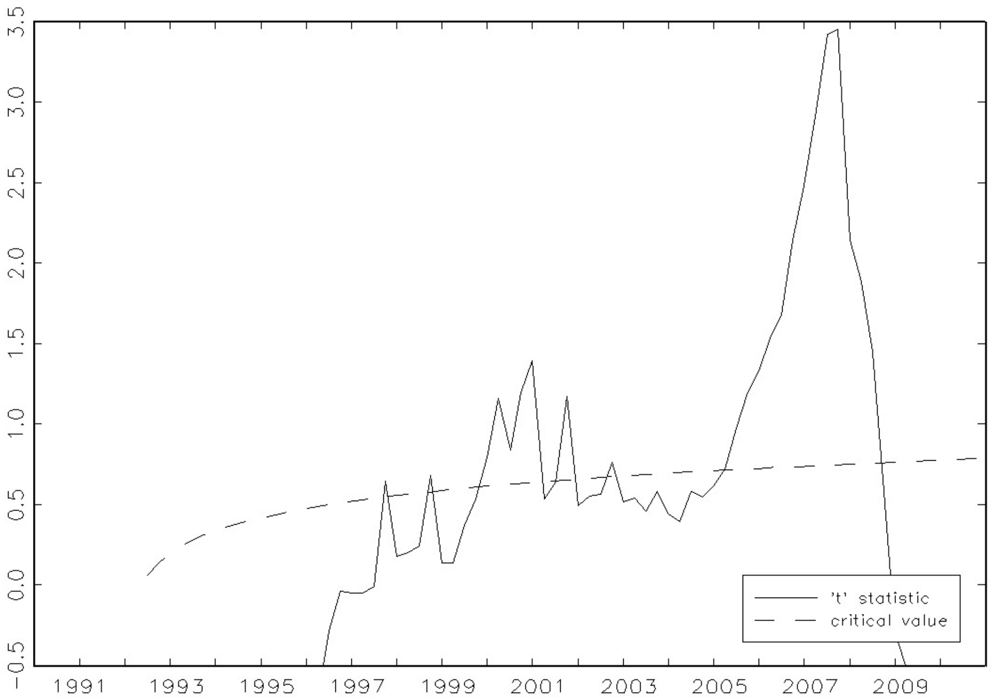

Figure 2: Recursive values of the t statistics