Research Technical Paper

Assessing the Role of Income and Interest Rates in Determining House Prices

Kieran McQuinn   Gerard O'Reilly[*]

Abstract

Property prices across many OECD countries have witnessed remarkable increases over the past 10 years. Two factors frequently posited for this boom are higher income levels and the benign interest rate environment experienced in many of these countries. However, empirical models of house prices struggle to achieve credible results concerning the impact of interest rates with coefficients that are frequently insignificant or of the wrong sign. In this paper we propose an intuitive theoretical model of house prices where the demand for housing is driven by how much individuals can borrow from financial institutions. This level of borrowing depends on disposable income levels and current interest rates. We empirically test this model by applying it to the Irish property market. Our results support the existence of a long-run relationship between actual house prices and the amount individuals can borrow with plausible and statistically significant adjustment to this long run equilibrium.

1 Introduction

The persistence of the present boom in international property prices is unparalleled in recent times. Over the five year period 2000-2005, estimates by *The Economist*[1] reveal that the value of residential property in developed countries rose by over 30 trillion dollars - an increase equivalent to 100 per cent of those countries combined GDPs. In North America and across Europe, countries have experienced record highs in terms of house price to income ratios. Inevitably, the concern amongst policy-makers is the inherent stability and sustainability of this asset price increase - are property markets overvalued and if so, by how much? As noted by Case and Shiller (2003), the international media has, of late, been saturated with stories/analyses documenting the imminent "collapse" of property bubbles.

Reviewing studies of cross-country property markets reveals some agreement in identifying the underlying determinants of the demand and supply of housing. Two of the key drivers frequently cited in the recent run up in house prices has been rising income levels and the benign interest rate environment faced by many countries. Less agreement, however, is forthcoming on the theoretical and empirical approaches used to model these factors. For example, it is not uncommon for price levels in the same property market when analysed with two different (and popular) approaches to be deemed either "determined by fundamentals" and consequently, sound or, conversely, "dangerously overvalued".

It is possible to separate much of the existing literature into two broad approaches. The first we call the "econometric" approach whereby a reduced form price equation is estimated based on some underlying notion of the determinants of supply and demand. Typically, house prices are regressed on a set of potential determinants. The fitted values from the regression are then interpreted as the price level justified by fundamentals within the economy and the potential stability of the asset price increase is gauged by comparing this fundamental price with the actual price level.[2] One of the problems with this approach is that variables which are believed, a priori, to be important in house price determination such as interest rates often appear with the wrong sign or are found to be insignificant. For example, in

---

[1] Volume 375, Number 8431, 2005.

[2] Examples of this type of approach can be observed in Poterba (1991), Mankiw and Weil (1989), Muellbauer and Murphy (1997), Roche (2001) and Fitzpatrick and McQuinn (2007) amongst others.

models estimated for eight different US States, Case and Shiller (2003) acknowledge that the mortgage rate had an insignificant coefficient in all but one of the regression models. Mayer (2003) also notes that the results from such regression models suggests that, historically, house purchase behaviour and housing values may not have been very responsive to changes in interest rates.

An alternative, more finance-based, approach taken in the literature can be characterised by an underlying notion of arbitrage where the returns to investing in housing relative to some other asset are evaluated or the costs and benefits of renting relative to buying are compared. One standard metric used in this context is the ratio of rental income to house prices. Deviations of the current rental price ratio from its long-run average are frequently taken to be an indication of over or undervaluation.[3] A more sophisticated implementation of this approach, based on the methodology of Campbell and Shiller (1988a,b) has been recently applied to the US housing market by Campbell, Davis, Gallin and Martin (2006). In this type of model, a tight relationship is imposed between house prices and interest rates. This contrasts with the former, econometric approach where the interest rate variable enters in freely into the regression specification and can often be "swamped" in the estimation yielding a very small and minor semi-elasticity effect.

However, one of the potential drawbacks of many finance based approaches is that underlying supply and demand factors such as income or demographics are not modelled. Rather, these factors enter indirectly by affecting either the growth rate of rental income or in terms of a changing discount factor. Moreover, this approach has little to say regarding any adjustment path for house prices if house prices are away from their fundamental level. In recent times many of these finance-based indicators such as the rental price ratio have deviated substantially from their long-run average for a number of different housing markets. OECD (2005) illustrate this fact for 14 out of the 17 international housing markets examined.[4] However, the implied overvaluation from such measures is, at times, at variance with the results from reduced form econometric models, which tend to suggest far less evidence of overvaluation.

---

[3]The Economist magazine regularly posts a survey based on house price developments in a number of country capitals based on rental price ratios.

[4]Campbell, Davis, Gallin and Martin (2006) find similar results for the four census regions of the US.

In this paper, we propose a simple intuitive theoretical model of the housing market which captures the important role of credit, income and interest rates as drivers of housing demand but also resolves some of the difficulties of previous approaches already highlighted. More specifically, we model the demand-side determinants of house prices as a function of the average amount borrowed by households given current disposable income levels and interest rates. In reality, the amount lent by a mortgage institution to an individual is critically dependent on current disposable income and interest rates. Based on this observation, we back out how much a financial institution would lend an individual given plausible assumptions regarding the fraction of income that goes to mortgage repayments and the duration of the mortgage using a standard annuity formula. Ultimately, this value should be an important determinant of housing demand. We believe this model captures the fact that most house purchases are mortgage-financed and the amount that mortgage providers are willing to lend is ultimately a function of income and interest rates.

In contrast to the finance approach, however, we do not derive a "fundamental" price level and then compare it with the actual level. Instead, we estimate both a long-run relationship between house prices and the amount that can be borrowed and a short-run model that examines the speed of adjustment when there is a deviation from the long run equilibrium. We apply the model to the Irish property market. This market has been to the fore of the international trend of rising house prices. Over the ten year period 1995 - 2005, prices for new Irish houses rose by almost 260 per cent. Given the exceptional performance of the Irish economy over the same period, the Irish housing market is a particularly interesting case study of rising house prices in the context of increasing income levels and a low and stable interest rate enivornment. The former is attributed to the rise of the so called Celtic Tiger while lower interest rates have coincided with Ireland's entry and membership of the European Monetary Union (EMU).

We believe our model draws upon the advantages of both the econometric and finance based models while avoiding some of their drawbacks. In combining a theoretical and an empirical model, we think our approach has a number of merits to recommend it. First, the model is intuitively appealing, familar as it is to most people who have taken out a mortgage. In addition, it models, in a plausible fashion, how mortgage institutions decide how much to lend.

Secondly, since we impose a realistic theoretical relationship between interest rates, income and how much one can borrow, we avoid the shortcomings of having an insignificant or incorrectly signed interest rate response - something that is characteristic of much of the previous literature. Accordingly, the proposed model is particularly useful for scenario analysis aimed at capturing the effects of changes in income and interest rate movements on house prices. This is important in light of the recent monetary tightening by policymakers in both the euro area and the US. Previously mentioned models would implausibly suggest little or no impact of higher interest rates on house prices. To further illustrate this point, we conduct a counterfactual exercise in assessing what impact the lower interest rate environment experienced by the Irish economy since joining monetary union has had on house prices relative to a regime where an independent monetary policy was pursued.

Finally, in estimating our long and short-run models, we achieve plausible and robust results in terms of the relationship between the actual and predicted price levels. This contrasts with issues of fit which can arise with the more finance-based models where the price suggested by, say, rental price ratios, are often quite out of kilter with the actual observed price.

The rest of the paper is organised as follows; in the next section we introduce our theoretical model of house prices. We then discuss the Irish housing market, while the following section describes the empirical approach adopted in this paper. The results of the empirical approach are next discussed and we assess whether Irish house prices are overvalued. Finally, we conduct our counterfactual exercise and offer a brief conclusion.

2   A Theoretical Model of House Prices

In considering a model of house prices we define the following variables

$$
\begin{aligned}
P_t &= \text{actual house prices.} \\
B_t &= \text{amount that can be borrowed.} \\
S_t &= \text{supply of housing.} \\
Y_t &= \text{disposable income per household.} \\
R_t &= \text{mortgage interest rate.} \\
\tau &= \text{duration of mortgage.} \\
\kappa &= \text{proportion of household income going on mortgage repayments.}
\end{aligned}
$$

In our model, we concentrate on the role played by the demand-side factors – income and interest rates. In particular, we argue that the demand for housing is mainly a function of the amount that prospective house purchasers can borrow from financial institutions and this, in turn, is dependent on current disposable income and the existing mortgage interest rate. The relationship between income levels, interest rates and the typical amount of a mortgage offered by a financial institution is generally based on the present value of an annuity. The annuity is the fraction of current disposable income κY_t that goes toward mortgage repayments and is discounted at the current mortgage interest rate for a horizon equal to the term of the mortgage τ. Thus, the amount that can be borrowed B_t is given by

$$
B_t = \kappa Y_t \left(\frac{1 - (1 + R_t)^{-\tau}}{R_t} \right). \tag{1}
$$

This mimics the reality that people seek to maximise the amount they can borrow subject to the lending criteria of mortgage lending institutions. Our approach is closely related to the notion of a housing affordability index frequently used in assessments of the housing market.[5]

---

[5]This concept measures the ratio of an average monthly mortgage payment based on current interest rates to average family monthly income. The National Realtors Association in the United States publishes a monthly Housing Affordability Index (HAI), which is quoted frequently by the Wall Street Journal in its commentaries on the US market. See, for example, http://www.realestatejournal.com/buysell/markettrends/20051223-simon.html

The amount that can be borrowed is then incorporated within the following inverted demand function

$$P_t^D = \left[\kappa Y_t \left(\frac{1 - (1 + R_t)^{-\tau}}{R_t}\right)\right] S^{-\mu}.$$ (2)

In other words, we assume a downward sloping demand curve with the own price elasticity of demand for housing represented by the inverse of the parameter μ. This curve can be shifted due to changes in income or interest rates. An inverse housing supply equation is given by

$$P_t^S = S^\phi,$$ (3)

where housing supply is a positive function of price and the own price elasticity of supply is given by the inverse of the parameter ϕ. In the short-run, supply is assumed to be inelastic, i.e. $S = \overline{S}$. Therefore, the short-run price of housing depends on the amount that can be borrowed. In order to derive the long-run equilibrium price level, we take logs of equations (2) and (3) and solve, yielding the following expression for the long-run price

$$p^{LR} = b\left[\frac{\phi}{(\phi + \mu)}\right]$$ (4)

where lower case refers to variables in logs. This price is a function of how much can be borrowed, and the slopes of the demand and supply curves.

Deriving an estimate of B in equation (1) requires certain assumptions. For example, in our baseline calculations we assume a mortgage length of 25 years.[6] However, we examine the sensitivity of our results to this and other assumptions made. In the next section, we provide an overview of the Irish property market.

---

[6]We assume that the fraction of disposable income that goes on mortgage repayments, is set at 0.30. However, as our model is log-linear, κ can easily be seen to be a scaling parameter, which does not affect the estimated $\left[\frac{\hat{\phi}}{(\phi+\mu)}\right]$ parameters. So, in estimation as κ is subsumed into the intercept term, technically no assumption concerning its size is required if we wish to uncover the response of house prices to the amount borrowed.

3   The Irish Housing Market

Over the sample period considered (1980 - 2005), the Irish economy has experienced profound economic change. Ireland, in the 1980's, witnessed negligible economic growth, an average unemployment rate of 14 per cent and high levels of personal taxation. The emergence of the so-called *Celtic Tiger* in the mid 1990s led to a sustained period of economic growth. Between 1995 and 2005, the size of the economy doubled with the total number of people employed in the country increasing by almost 50 per cent. This sustained increase in income levels was coupled with a stable, low interest rate environment. The change in economic conditions is highlighted in Figure 1, which plots the the growth rate of house prices, monthly disposable income per household and the variable mortgage interest rates over the sample period. In the first panel of Figure 1, the large increase in house price growth can clearly be seen throughout the 1990s - between 1995 and 2005 it averaged over 12 per cent per annum. Disposable income per household in panel 2 of Figure 1 also grew exceptionally throughout this period due to the high level of economic growth and reductions in personal taxation levels. By the end of the sample, monthly take home income was over 6 times the level it had been in 1980. Panel 3 of Figure 1 illustrates the highly benign nature of the present interest rate environment, when compared with the more turbulent early 1980s and 1990s.

The length and size of the house price increase, as might be expected, has provoked considerable academic interest. A non-exhaustive review of the literature dealing with Irish house prices over the period of the rapid price appreciation reveals studies by Murphy (1998), Kenny (1999), Conniffe and Duffy (1999), Roche (1999, 2001 and 2003), McQuinn (2004), Fitzpatrick and McQuinn (2007) and Duffy, Fitzgerald and Kearney (2005). Most of the empirical work estimates a fundamental house price typically with a reduced form model.

In so far as these reduced form models have been used to evaluate the stability of the price increases, results from Roche (2001 and 2003), McQuinn (2004) and Fitzpatrick and McQuinn (2007) would suggest that actual prices are well explained by fundamental factors within the economy. However, this contrasts with the interpretation of alternative valuation methods such as the rental price ratio. Figure 2 plots the Irish rental price ratio for 1980 - 2005.[7] It is evident from this figure that

---

[7] This is defined as the ratio of annualised rent values to the price of new house for that quarter.

the ratio of rents to house prices followed a relatively stable path throughout the 1980s and the first half of the 1990s. Thereafter, the ratio has fallen substantially with the rapid increase in Irish house prices outstripping the growth in rents. By the end of 2005, the value of the ratio was 64 per cent less than the 1980-1995 average. Based on this observed decline in the rental-price ratio, *The Economist*, amongst others, has forcefully argued that Irish house prices (along with those of Spain and the UK) are highly overvalued and the likelihood is that prices will fall. The 2005 Financial Stability Report of the Central Bank and Financial Services Authority of Ireland (CBSFAI) also concluded that the "potential misalignment" of house prices relative to rents could be between 50 and 70 per cent. This contrast in policy conclusions based on different empirical approaches is not necessarily specific to the Irish market.

The data used in the study is quarterly and covers the period 1980:1 to 2005:4. Disposable income and interest rate data are obtained from a macro-economic model database created and maintained in the CBFSAI (see McGuire et al. (2002) for more details on this). The house price series used refers to new house prices and is taken from the Irish Department of the Environment's *Housing Statistics Bulletin*.[8] Data on the number of households are available from the Irish Central Statistics Office (CSO) and we interpolate this data to arrive at a series for disposable income per household at a quarterly frequency.

In terms of interest rates, the vast majority of mortgage credit during our sample is at variable rates. Variable rates (rates that are fixed for a period less than one year) account for about 80 per cent of the outstanding stock of mortgage debt and about the same amount of new lending during 2005. Hence, we use a variable rather than a fixed mortgage rate in our study.

Table 1 presents a summary of the relevant data over the sample period. The correlation between the actual price level and the amount that can be borrowed based on equation (1) is 0.989. The high correlation between the series would suggest a long term relationship between actual house prices and the price based on the average amount borrowed. In the next section, we explore this relationship in a more formal statistical setting presenting unit root and cointegration test statistics.

The rent values are based on the CSO rental price index.

[8]We use new house prices in our analysis mainly on the basis that Roche (2003) demonstrates that new Irish house prices Granger-cause second hand house prices but not the other way around.

3.1 Empirical Approach

Table 2 reports the results for a battery of unit root tests for both the log of actual house prices p_t and the log of the amount that can be borrowed b_t. In particular, we report results from three tests of the null hypothesis that each series contains a unit root. The first is the standard Augmented Dickey-Fuller t-test; the second is the DF^{GLS} test of Elliot, Rothenberg and Stock (1996) which has superior power to the ADF test; the third is the $\bar{M}Z_{\alpha}^{GLS}$ test of Ng and Perron (2001) which has been shown to have excellent size and power properties. For each test, the lag length for the test regressions was chosen using Ng and Perron's Modifed AIC procedure. In all three cases, the tests fail to reject the unit root hypothesis at the 5 per cent level of significance. A natural concern using nominal prices is that they could be integrated of order (2). However, testing first differences of both series rejects this hypothesis.

We next test whether there is evidence of cointegration between the actual price and the amount that can be borrowed based on Johansen's (1995) systems approach to testing for cointegration. These results are also reported in Table 2. Both the trace and lambda max test suggest the presence of one cointegrating vector. Based on the cointegration results, we next proceed to estimate a long-run relationship between the logs of the actual house prices and the amount that can be borrowed. We use the dynamic ordinary least squares (DOLS) methodology of Stock and Watson (1993). The DOLS estimator falls under the single-equation Engle Granger (Engle and Granger (1987)) approach to cointegration while allowing for endogeneity within the specified long-run relationships. Single equation approaches have been used in other models of the housing market, such as Muellbauer and Murphy (1997) and Fitzpatrick and McQuinn (2007).

The Stock and Watson (1993) DOLS approach explicitly allows for potential correlation between explanatory variables and the error process. It is best explained by an example; if we take the potential long-run relationship below

$$y_t = \beta_0 + \beta_1 x_{1t} + \beta_2 x_{2t} + \epsilon_t. \tag{5}$$

where either x_{1t} or x_{2t} may be endogenous, DOLS involves adding both leads and

lags of the differenced regressors to the specification to correct for correlation be-
tween the error process ϵ_t and the level regressors

$$y_t = \beta_0 + \beta_1 x_{1t} + \beta_2 x_{2t} + \sum_{j=-k}^{k} \theta_{1j} \triangle x_{1,t+j} + \sum_{j=-k}^{k} \theta_{2j} \triangle x_{2,t+j} + \epsilon_t. \tag{6}$$

The error term in (6) is liable to be serially correlated so the covariance matrix
of the estimated coefficients must be adjusted accordingly.[9] In our application, ϵ_t is
assumed to follow an AR(2) process, while k - the number of leads and lags is set
equal to 2.[10]

Table 3 presents the results for the following long-run model

$$p_t = \alpha + \gamma b_t. \tag{7}$$

where lower case denotes logs. From the results, it can be seen that the coefficient
γ is equal to 0.81. The associated t-statistic suggests that the amount borrowed
is a highly significant determinant of new house prices in the long-run. A priori,
one would not expect γ to be equal to unity. The amount that can be borrowed
comprises only part of the inverse demand function in equation (2) - it does not
include the responsiveness of supply over the longer run to price movements. Recall
that the more elastic supply is, i.e., the greater the size of $[\frac{\phi}{\mu+\phi}]$ in equation (4),
the smaller will be the long-run relationship between the actual price and the price
suggested by equation (7).

3.2   Robustness

The current specification assumes certain values for the length of the mortgage
term τ. We assess the robustness of our results to variations in this assumption.

---

[9]This involves modifying the covariance matrix of the original regressors by specifying and
estimating an AR(p) model for the error term in (6). See Fitzpatrick and McQuinn (2007) for
more on this.

[10]We experimented with alternative values of k and length of the AR() process, however, our
results were not significantly changed. Parameter estimates for the leads and lags in the DOLS
estimation are available, upon request, from the authors.

In Table 4 we report estimates of equation (7) based on the DOLS estimator for differing mortgage maturity terms: 15, 20 and 30 years. As can be seen, estimates for γ do not change dramatically based on different mortgage lengths. Estimates of γ are in the range 0.78 to 0.91. With respect to the fraction of income that goes toward monthly mortgage repayments, since the estimated long-run relationship in equation (7) is in logs, differences in κ will appear in the constant term only.

One potential criticism of our approach is the relative parsimony of the specification in equation (7). Our assumption is that the amount borrowed, b_t, adequately proxies demand in the Irish housing market. We did include some additional demand side variables in our specification, however, the explanatory power of the long run equation was not increased significantly.[11]

We also estimate the long-run cointegrating relationship using Philips and Hansen's (1990) fully modified ordinary least squares estimator (FM-OLS). This method corrects OLS for possible serial correlation and endogenity in the regressors that results from the existence of a cointegrationg relationship. These results are also reported in Table 3 and correspond very closely to the results previously reported based on the DOLS estimator.

Another potential concern with our results is that given the dramatic changes in Irish economic conditions over the sample period any relationship found might be highly unstable. We assess the stability of the cointegrating relationship using Hansen's (1992) battery of tests for parameter instability based on the FM-OLS estimator. These are reported in Table 5 with all tests failing to reject the null hypothesis of stability of the cointegrating relationship.

3.3 Overvaluation?

Inevitably, given the persistent nature of the housing boom in Ireland (and abroad), policy-makers are particularly concerned with the issue of potential overvaluation. In an Irish context, this concern is amplified somewhat by the duration of the asset price increase and the increased reliance of certain sectors of the economy on the housing sector. For example, between 2000 and 2005, on average, 64,000 housing units were built in Ireland per annum. This is over a third of the amount

---

[11]These additional variables included loan-to-value ratios and demographic variables.

constructed in the UK over the same period - even though the population of the UK is approximately 14 times larger. Over the same period the total number employed in the Irish construction sector has increased by almost 45 per cent, while tax receipts from housing in 2005, accounted for almost 12 per cent of the total tax take.

We assess the presence (or lack) of overvaluation in the Irish market, by examining the relationship between actual house prices and the long-run "fundamental" price suggested by our DOLS estimate. Comparing the actual and fundamental price as a means of gauging potential overvaluation is a standard approach in the literature and has been recently employed by Case and Shiller (2003) and Roche (2001) amongst many others. Hence, given the long-run relationship estimated between Irish house prices and the amount borrowed, are Irish prices currently, persistently above this fundamental level?

We compare actual house prices with the fitted values from equation (7) in Figure 3. As can be seen from this plot, the model is able to explain actual house prices quite well over the sample period with predicted house prices tracking actual house prices closely over time. This is despite the fact that there were dramatic changes in economic conditions over the sample period.

A comparison of the two price series also reveals periods of both under and over valuation during the sample. For example, there would appear to have been persistent undervaluation in the Irish housing market over the period 1993 - 1997. Interest rates and income levels during this period suggested that actual prices should have been higher. This period, of course, immediately preceeded the present boom era, suggesting perhaps that it took time for Irish house purchasers to realise the improvement in prevailing house purchasing conditions. On the other hand, around 2000, the ECB increased interest rates, thereby causing a decline in the fundamental price, nonetheless, actual prices stayed on an upward trend. The two prices converged again and remained closely related until the end of 2003. From then on there has been a noticeable gap between the actual and fundamental prices, which, given its persistent nature, is suggestive of some overvaluation. This gap is increasing and, at the end of the 2005 Q4, the degree of overvaluation would appear to be, approximately, 15 per cent.

It is worth remembering that the degree of change in house prices will ultimately

depend on what will happen to the future path of income and interest rates. Even if prices are overvalued, any potential fall in prices can be mitigated or overturned completely by rising income levels or declining mortgage rates.

A natural question is whether our results regarding potential overvaluation are robust to alternative values for both the mortgage length τ and the fraction of current income spent on mortgage repayments κ respectively? Varying the mortgage term between 15 and 30 years gives a very similar quantitative picture regarding the deviation of actual house prices from their predicted values and this is illustrated in Figure 4. In particular, this figure plots the percentage divergence between actual and predicted house prices for differing mortgage maturities. With respect to the fraction of income devoted to mortgage repayments, varying κ between 0.20 to 0.35 makes a neglible difference to our results regarding the divergence between actual and predicted house prices.[12]

3.4 Error Correction Model

Having found a long-run relationship between actual house prices and the amount borrowed, two natural questions then arise: 1) if actual prices deviate from this long run relationship are there equilibrating forces that will bring us back to equilibrium? 2) If this is the case, what is the speed at which actual house prices return to their long run equilibrium? In this section we seek to answer both these questions by estimating the short-run dynamics of our theoretical model. In particular, we seek to estimate the degree of error correction by the growth rate in actual house prices to the long-run relationship between the log of actual house prices and the log of the amount, which can be borrowed. Two variants of the short-run model are estimated. The first model (Model 1) is the following

$$\triangle p_t = \lambda \left(p_{t-1} - \alpha - \gamma b_{t-1} \right) + \sum_{i=1}^{4} \theta_i \triangle p_{t-i} + \sum_{i=0}^{4} \theta_{i+5} \triangle b_{t-i} + u_t. \tag{8}$$

where we simultaneously estimate the degree of error correction along with the long-run parameter γ. The estimate of γ from the error correction model can be compared with the estimates from DOLS or FM-OLS. A potential concern with

---

[12]The latter calculations are available on request.

using a single equation approach such as the error correction model in equation (8) is that the amount that can be borrowed should be weakly exogenous with respect to the actual price. Testing this hypothesis, based on a likelihood ratio test which is χ^2 distributed, leads us to fail to reject the null of weak exogenity with a p-value of 0.124.

The second model, (Model 2), also estimates short-run parameters. However, in this instance they are conditional on the DOLS long-run results. This results in the following estimated regression

$$\triangle p_t = \lambda \left(p_{t-1} - \alpha^{DOLS} - \gamma^{DOLS} b_{t-1} \right) + \sum_{i=1}^{4} \theta_i \triangle p_{t-i} + \sum_{i=1}^{4} \theta_{i+4} \triangle b_{t-i} + u_t. \quad (9)$$

where λ is again the speed of error correction and γ^{DOLS} and α^{DOLS}, are the previous estimates of the long run parameters from Table 3 based on DOLS. A summary of the estimation results for both models are presented in Table 6. For both models a "general-to-specific" procedure was performed with the elimination of insignificant lags. Mis-specification tests, performed on both regressions, would suggest that the error processes, in both cases, are well-behaved.

From this table, it can be seen that the estimate of γ from Model 1 is higher than that estimated with DOLS, however, the magnitude is of the same order - 0.99 as compared to 0.81. This result highlights the close relationship between the actual price and the amount borrowed. In both models, there is strong evidence of error correction - the coefficient λ is negative and significant. The results are very similar, with Model 1 suggesting almost 4.5 per cent error correction per quarter, while Model 2 suggests almost 5 per cent.

3.5   Counterfactual Exercise

It has been argued by many commentators that the move to monetary union has led to Irish interest rates being lower than would have been the case had an independent monetary policy been followed. Two reasons for this are 1) the removal of exchange rate uncertainty which had previously driven a wedge between German and Irish interest rates and 2) if monetary policy is characterised by 'leaning against the wind', policy makers would likely have set domestic interest rates at a higher rate

14

due to the positive growth and inflation differentials observed between Ireland and the rest of the euro area.

It has also been suggested that this low interest rate environment has been a major contributory factor to the sustained rise in Irish house prices. In order to assess the merits of such a view, we simulate the impact on predicted house prices in our model had interest rates been 2 percentage points higher than observed since the start of monetary union. We use the short-run model in (9) to simulate the effect of the higher rate. In Figure 5, we compare the predicted house price based on the actual mortgage rate (Actual) and our counterfactually higher mortgage rate (Counterfactual) and find that house prices as of 2005:Q4 would have been 22 per cent lower in the counterfactual higher interest rate regime. Of course standard reduced form models which find an insignificant role of interest rates would contradict this view.

The problem of a country experiencing a property boom, while relatively constrained in adopting monetary policy levers, which may be employed in tempering such rapid asset price increases, has been commented upon by Fitzpatrick and McQuinn (2007). The issue is likely to be of interest to future possible entrants into the euro area such as the UK where, for example, the greater sensitivity of UK households to interest rate fluctuations vis-à-vis other EU countries has been noted.[13]

4   Concluding Comments

The role of interest rates as a primary determinant of house price movements is virtually uncontested. However, economic models of house prices have struggled to successfully "incorporate" the effects of interest rate movements. In this paper we propose that the house price demand schedule can be adequately represented by the average amount borrowed, which is determined on the basis of prevailing disposable income levels and interest rates.

This approach has a number of attractions. It imposes a certain theoretical rigour on the relationship between house prices, interest rates and income lev-

---

[13]See 'Housing, consumption and EMU' in 'The EMU study' by HM Treasury available online at: http:www.hm-treasury.gov.uk

els while the subsequent econometric model produces credible results and a useful framework for simulation analysis. It is also recognisable to most mortgage applicants as the formula adopted by financial institutions in gauging mortgage affordability levels for prospective house-owners.

Our results do indeed reveal co-integration between actual house prices and the level suggested by the average amount borrowed. This long run result is robust across different estimators and various different parameter assumptions concerning mortgage schedules.

Finally, scenario analysis highlights the importance of the low-interest rate environment experienced recently in the Euro-zone in stimulating Irish house price increases. A noticeable change in Euro-wide monetary conditions allied to a moderation in general economic growth is likely to have a direct and significant impact on Irish house prices.

References

[1] Breusch, T. (1978). "Testing for autocorrelation in dynamic linear models," *Australian Economic Papers*, 17, 334-55.

[2] Campbell, J. and R.J. Shiller (1988a). "The dividend price ratio and expectations of future dividends and discount factors," *Review of Financial Studies*, 1, 195-227.

[3] Campbell, J. and R.J. Shiller (1988b). "Stock prices, earnings and expected dividends," *Journal of Finance*, 43, 661-676.

[4] Campbell, S., Davis, A., Gallin, J. and R.F. Martin (2006). A trend and variance decomposition of the rent-price ratio in housing markets, 2006-29 (August), Finance and Economics Discussion Paper, Federal Reserve Board.

[5] Case, K.E. and R.J. Shiller (2003). "Is there a bubble in the housing market?" *Brookings Papers on Economic Activity* 2:2003, 299-342.

[6] Conniffe, D. and D. Duffy (1999), "Irish house price indices - Methodological issues" *The Economic and Social Review*, 30, No. 4, 403-423.

[7] Duffy, D., Fitzgerald, J. and I. Kearney (2005), "Rising house prices in an open labour market" *The Economic and Social Review*, 36, No. 3, 251-272.

[8] Elliot, G., Rothenberg, T. and Stock, J. (1996). "Efficient Tests for an Autoregressive Unit Root," *Econometrica*, 64, 813-836.

[9] Engle, R. (1982). "Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation," *Econometrica*, 50, 987-1008.

[10] Engle, R. and Granger, C. (1987). "Cointegration and error-correction: Representation, estimation and testing," *Econometrica*, 55, 251-76.

[11] Fitzpatrick, T. and K. McQuinn (2007). "House prices and mortgage credit: Empirical evidence for Ireland", *The Manchester School*, (forthcoming).

[12] Financial Stability Report 2005, Central Bank and Financial Services Authority of Ireland.

17

[13] Godfrey, L. (1978). "Testing against general autoregressive and moving average error models when the regressors include lagged dependent variables," *Econometrica*, 46, 1293-1302.

[14] Hansen, B.E. (1992). "Tests for parameter stability in regressions with I(1) variables," *Journal of Business and Economic Statistics*, 10(3), 321-325.

[15] Johansen, S. (1995). *Likelihood-Based Inference in Cointegrated Vector Autoregessive Models*, Oxford University Press.

[16] Kenny, G. (1999). "The housing market and the macroeconomy: Evidence from Ireland," *Economic Modelling*, 16, 389-409.

[17] Mankiw, N. and Weil, D. (1989). "The baby boom, the baby bust and the housing market," *Regional Science and Urban Economics*, 19, 235-58.

[18] Mayer, C. (2003). "Is there a bubble in the housing market? - Comments and Discussion" *Brookings Papers on Economic Activity* 2:2003, 343-354.

[19] McGuire, M., O'Donnell, N. and Ryan, M. (2002). Interpolation of quarterly data for ECB/NCB multicountry modelling exercise - Data update to 1999q4, Research Paper, Central Bank and Financial Services Authority of Ireland.

[20] McQuinn, K. (2004). A model of the Irish housing sector, Research Technical Paper 1/RT/04, Central Bank and Financial Services Authority of Ireland.

[21] Muellbauer, J. and Murphy, A. (1997). "Booms and busts in the UK housing market," *Economic Journal*, 107, 1701-1727.

[22] Murphy, A. (1998), Econometric modelling of the Irish housing market, in P. Bacon, F. McCabe and A. Murphy (eds), *An economic assessment of recent house price developments*, Stationary Office, Dublin.

[23] Ng, S. and Perron, P. (2001). "Lag Length Selection and the Construction of Unit Root Tests with Good Size and Power,'" *Econometrica*, 69, 1519-1554.

[24] OECD. (2005). Recent house price developments: The role of fundamentals, OECD Economic Outlook No. 78.

[25] Philips, P.C. and Hansen, B.E. (1990). "Statistical inference in unstrumental variables regression with I(1) processes," *Review of Economic Studies*, 57, 99-125.

[26] Poterba, J.M. (1991). "House price dynamics: The role of tax policy and demography," *Brookings Papers on Economic Activity*, 2, 143-203.

[27] Roche, M. (1999), "Irish House Prices: Will the Roof Fall In?" *The Economic and Social Review*, 30, No. 4, 343-362.

[28] Roche, M. (2001), "The rise in Dublin city house prices: Bubble, fad or just fundamentals" *Economic Modelling*, 18, No. 2, 281-295.

[29] Roche, M. (2003). Will there be a crash in Irish house prices?, ESRI quarterly economic commentary, Autumn, 57-72.

[30] Stock, J. and Watson, M. (1993). "A simple estimator of cointegrating vectors in higher order integrated systems," *Econometrica*, 61, 783-820.

Table 1: Summary of Data: 1980:1 - 2005:4

Variable		Mean	Std Error	Maximum	Minimum
House Prices	P_t	101,860	70,503	287,134	32,512
Interest Rates	R_t	8.89	3.76	16.25	2.85
Income per Household	Y_t	2,485	1,191	5,177	831
Borrowing	B_t	109,035	83,778	309,678	20,521

Note: All monetary variables are in Euros and nominal terms. The income figure is on a monthly basis and interest rates are in percentages.

Table 2: Unit Root and Cointegration Tests

	Unit Root Tests		
	p_t	b_t	5%
Test			
ADF t-test	-1.62	-2.80	3.40
ADF^{GLS}	-1.56	-2.64	2.91
$\bar{M}Z_\alpha^{GLS}$	-5.29	-14.18	17.3

Cointegration Tests

$H_0 : \text{r} = 0 \quad \text{r} > 1$

$H_1 : \text{r} \leq 1 \quad \text{r} = 2$

λ_{trace}	5%	10%
69.97	20.18	17.88
6.08	9.16	7.53

λ_{max}	5%	10%
63.90	15.87	13.81
6.08	9.16	7.53

Note: p_t is the log of the actual house prices and b_t is the log of the amount that can be borrowed. The sample period runs from 1980:1-2005:4. All unit root tests include a constant and a trend.

Table 3: Long-Run Model DOLS and FM-OLS Estimates

Variable	Parameter	DOLS Estimate	FM-0LS Estimate
constant	α	2.148	2.232
		(1.904)	(5.110)
b	γ	0.812	0.804
		(8.188)	(20.886)
R^2		0.950	0.945

Note: Figures in parenthesis refer to t statistics.

Table 4: DOLS estimates for alternative mortgage maturites.

Variable	Parameter	Mortgage Length (Years)			
		15	20	25	30
Constant	α	1.183	1.735	2.148	2.459
		(0.909)	(1.433)	(1.904)	(2.325)
b_t	γ	0.913	0.854	0.812	0.781
		(7.852)	(7.976)	(8.188)	(8.442)

Note: Figures in parenthesis refer to t statistics.

Table 5: Hansen's (1992) Tests for Stability of the Cointegrating Vector

Test	Test Statistic
L_C	0.253
MeanF	2.347
SupF	4.167

Note: All tests fail to reject the null hypothesis of stability of the cointegrating vector at 20 per cent level of significance.

	Table 6: Error Correction Models		
		Model 1	Model 2
Variable	Parameter	Estimate	Estimate
b_{t-1}	γ	0.995	
		(10.787)	
ECT_{t-1}	λ	-0.049	-0.054
		(-2.935)	(-3.104)
R^2		0.52	0.48
$AR(1)$		0.225	0.157
$AR(4)$		0.096	0.735
$ARCH(1)$		0.610	0.529
$ARCH(4)$		0.949	0.642

Note: Figures in parenthesis refer to t statistics. Model 1 refers to the simultaneous estimation of the long-run and short-run parameters, Model 2 is where the short-run parameters are estimated conditional on the predetermined DOLS long-run estimates. The results for both short-run models are after a general-to-specific procedure has eliminated insignficant lagged terms. Results are presented only for the parameters of interest. P-values are reported for the AR (Godfrey (1978) and Breusch (1978)) tests and ARCH (Engle (1982)) tests.

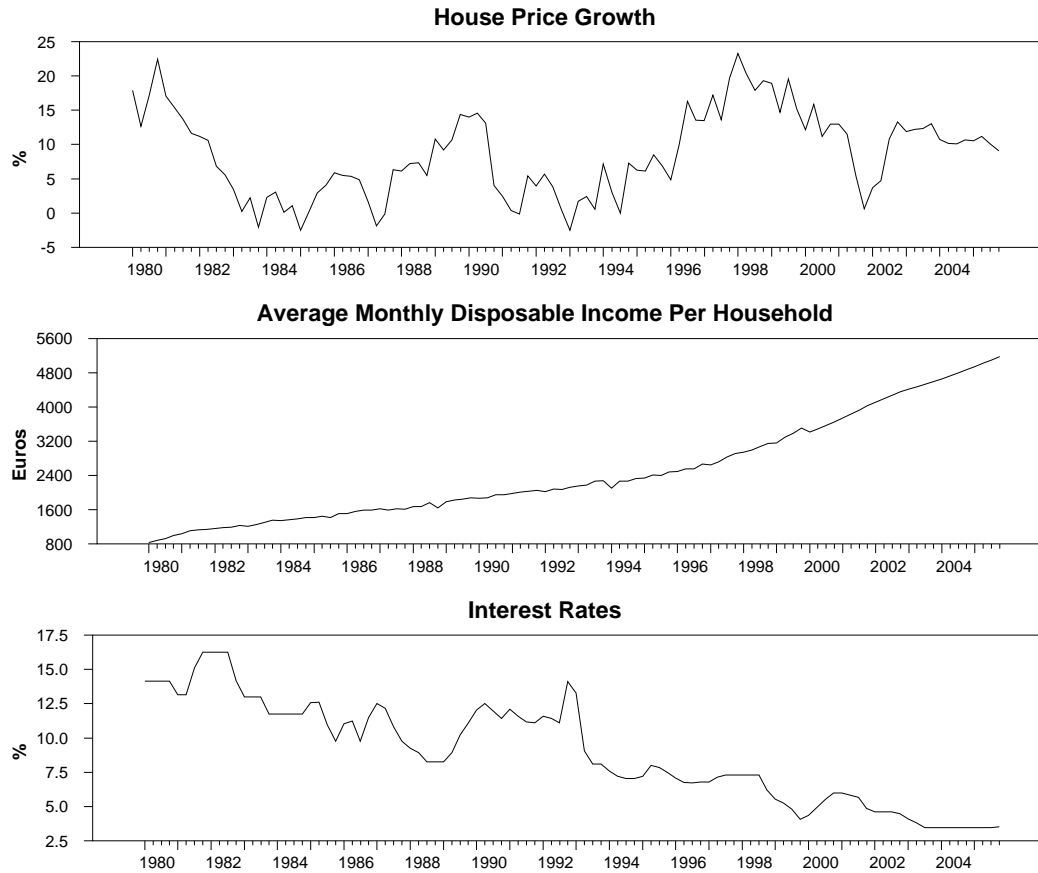# Figure 1: House Prices, Income & Interest Rates

House Price Growth

Average Monthly Disposable Income Per Household

Interest Rates

Figure 2: Ratio of Rent Levels to Irish House Prices 1980:1 - 2005:4
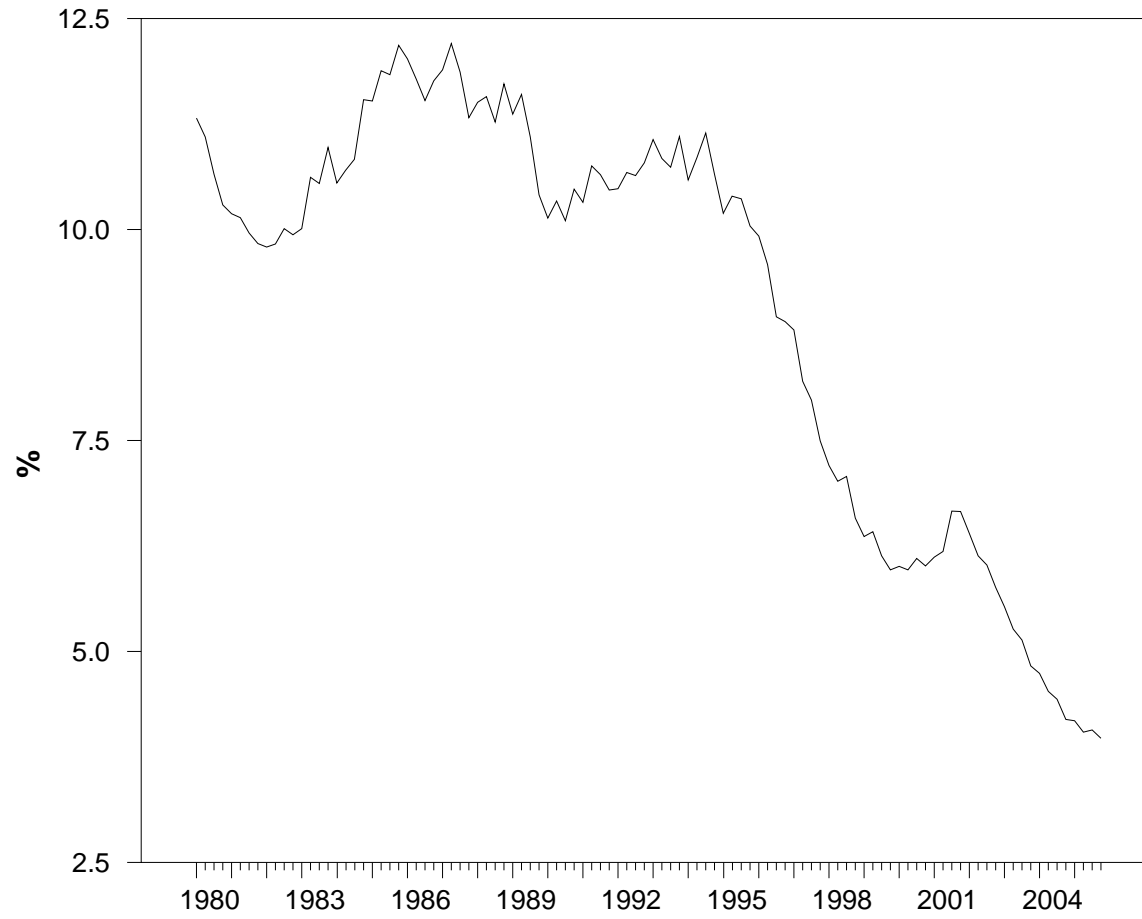
Figure 3: Fundamental Price and Actual House Prices
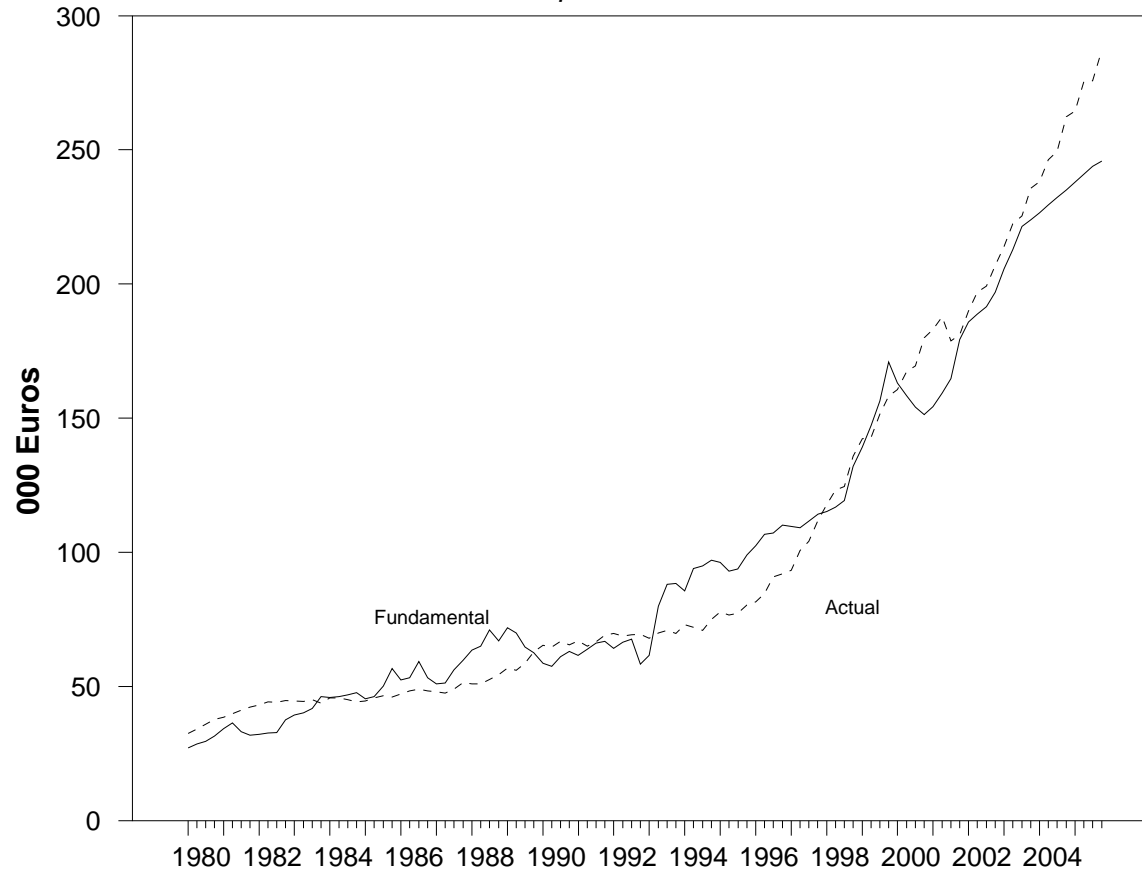
Fundamental price based on DOLS

Figure 4. Percent Deviation of Actual from Fundamental Prices based on DOLS
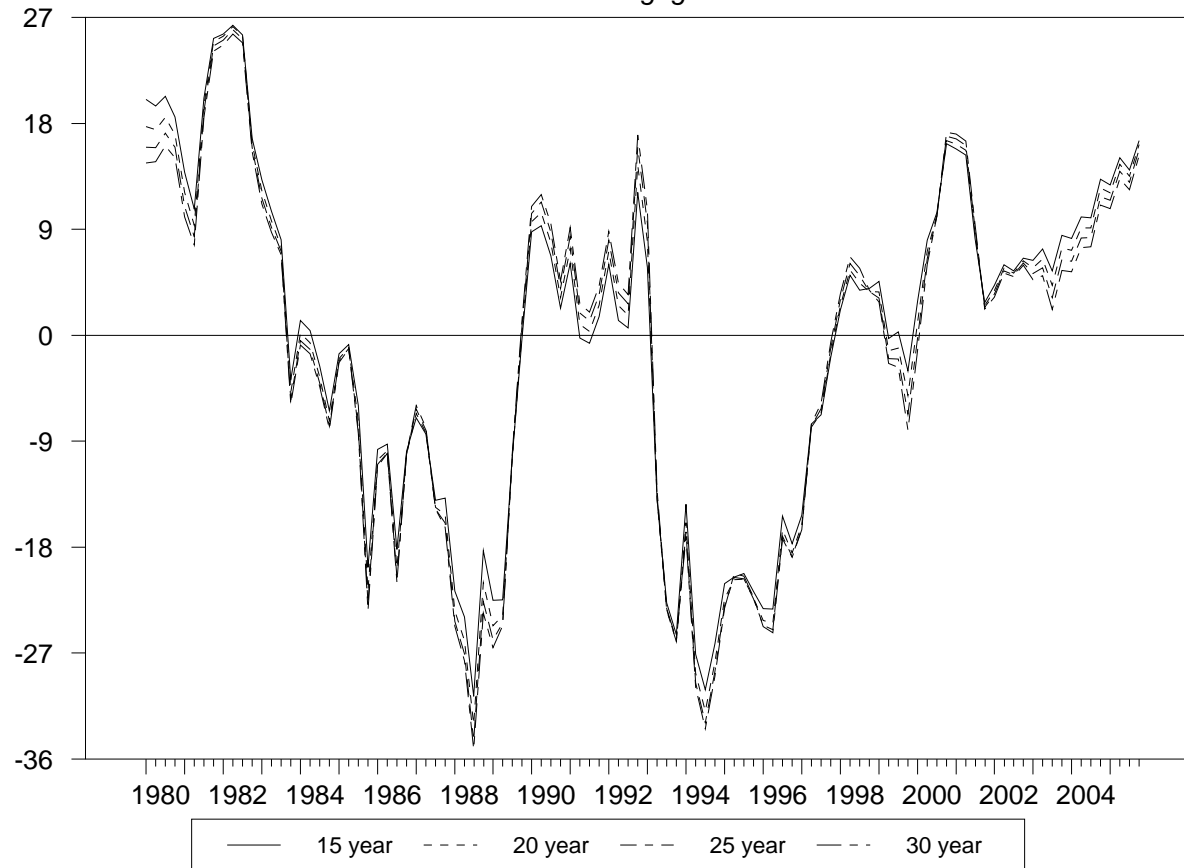
for different mortgage terms

Figure 5: Counterfactual Interest Rate Scenario