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A Model of the Irish Housing Sector

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Abstract

This paper presents a model of the Irish housing sector which has been created to nest within the Irish block of the ESCB multi-country model which is maintained in the Economic Analysis Research and Publications Department. The model consists of a demand and supply side and results from it are used to examine for the presence of a bubble in the Irish housing market.

1 Introduction

The persistent increase in Irish house prices over the past decade has provoked considerable comment across a wide plethora of opinion. Significant and persistent house price increases of the type witnessed in the domestic property market gives rise to the possibility of a speculative bubble and the consequent possibility of a collapse of such a bubble. A significant decline in house prices levels over a relatively short period of time poses difficulties on an economy-wide basis. Housing output in the Irish economy in 2002 amounted to almost 60,000 units, which is over seven times the per head of output in most EU countries. As a result, the construction industry in 2002 contributed over 15 per cent to national output. A decline in this level of activity in the housing/construction sector would have serious implications for the general economy. The value of housing represents a significant portion of personal wealth levels, a serious erosion of such levels would likely result in a negative wealth effect in the economy. Private sector consumption has contributed handsomely to the increased levels of Irish economic activity in recent years. Additionally, a serious decline in house prices would probably result in many householders having mortgages greater in value than the house itself i.e. negative equity. A significant increase in the rate of mortgage repayment defaults could pose serious questions for the stability of the domestic financial sector. From a macroeconomic perspective, therefore, an understanding is required of the dynamics of the housing market. The objective of this paper is to present a model of the Irish housing market within the context of the persistent speculation surrounding the future stability of Irish property prices. This model will then nest within the Irish block of the ESCB multi-country model for simulation and forecasting purposes.

The increased prominence of the housing issue in a national policy context is evidenced by the commissioning and subsequent publication of the Bacon report (see Bacon, MacCabe and Murphy (1998), Bacon and MacCabe (1999) and Bacon and MacCabe (2000) for details.) by the Irish Department of the Environment, Heritage and Local Government. The report presented certain measures primarily aimed at alleviating the demand side pressures in the housing market. These measures sought to restrict the role played by property investors in the market. The models underpinning the Bacon report's findings are detailed in Murphy (1998). Considerable interest in an Irish context has also centered on the quantification of the probability

of a bubble in the property/land market collapsing. Roche (1999), Roche (2001) and Roche and McQuinn (2001) for example, have applied the regime-switching model developed by Van-Norden (1996), Van-Norden and Vigfusson (1996a) and Van-Norden and Vigfusson (1996b) to Dublin and national price levels and agricultural land values. The regime-switching model applied enables both the detection of a speculative bubble and the estimation of the probability of such a bubble crashing. These relatively recent applications followed earlier empirical investigations of bubbles in property/land prices in an Irish context by Kenneally and McCarthy (1982), Thom (1983), Irvine (1984), Browne (1987), Browne and Fagan (1992) and Kenny (1998).

Of late, interest in the issue of a Irish house prices has been additionally stimulated by an international housing survey conducted by the 'Economist' magazine.[1] The survey suggests that international house price levels are overvalued for a number of countries including Ireland and a correction, re-aligning actual house prices to more fundamental prices, is a distinct likelihood. In particular, the survey predicts that Irish house prices will fall by upwards of 20 per cent over the next 4 years as they become more re-aligned with their perceived lower, longer-term equilibrium or fundamental values. This correction will take place in the presence of persistently low real interest rates and increases in wages and rents of 4 per cent per annum.

The rest of the paper is laid out as follows; the next section investigates the thinking behind recent predictions of housing price corrections and presents standard indicators of performance of the property sector. The following section presents an econometric model of the Irish housing market and a final section offers some concluding comments.

2   The Housing Market: Indicators of Performance

In analysing the housing sector, actual house prices (PA) are generally decomposed into their fundamental (PF) and non-fundamental (PNF) components. When PA deviates from PF, one of two states of speculative behaviour is said to exist

(1) a 'fads' model as developed by Summers (1986),

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[1] Edition May 29th 2003.

(2) or a stochastic 'bubbles' model proposed by Blanchard and Watson (1982).

The former arises where the actual house price fluctuates randomly around its fundamental value and, on average, the price is equal to the fundamental level. Intuitively, such a case may be thought of, as, where large numbers of house buying agents follow each other into the market. They witness an increase in the price and purchase before the price increases any further. Overtime, as fewer agents enter the market, the price reverts to that determined by market fundamentals.

In a technical sense, a stochastic bubbles situation exists, where the non-fundamental price behaves in a non-random fashion. PNF is then said to be made up of an explosive component if the bubble survives and a stationary component if it collapses. Rising prices, in this case, induce investors into the market in the pursuit of short-term capital gains. If enough investors enter the market, persistent upward movements in price, in time, become self-fulfilling prophecies.

In this section, as a precursor to an empirical model of the housing sector in section 3, a review is conducted of different measurement ratios and indicators used to approximate the fundamental price of housing. The ability of the public to sustain house price levels is also examined.

Two of the more generic measurement techniques in this regard are the price to income (PI) and the price to rent (PR) ratios. A substantial deviation in the price level of the house from both indicators, is frequently taken as good *a priori* grounds for the presence of a bubble. Figure 1 (insert Figure 1 here) plots both PI and PR for an average national house price on an annual basis from 1980 to 2002. Both ratios are expressed in index form (1990=100).[2] Clearly, both indicators have seen a considerable increase from 1996 onwards, the PR ratio in particular is 64 per cent above its 22 year average, while the PI ratio is almost 34 per cent above its average value. It is the sharp increase in these ratios, which prompted the Economist to state that a bubble exists in the Irish housing sector and that a painful correction is a foreboding eventuality.

While both sets of ratios have diverged from their longterm intrinsic values, both do not capture the increased affordability due to the relatively low interest rate envi-

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[2]The author would like to thank Terry Quinn (EARP) for the provision of most of the data used in the analysis. All data used is discussed in the appendix to the paper.

ronment evidenced since the mid 1990's. Nominal (MR) and real (RMR) mortgage interest rates confronting Irish consumers are plotted in Figure 2 (insert Figure 2 here) for the 1980-2002 time period. The relatively benign nominal and real interest rate environment of the late 1990's can be seen to coincide with the period of sustained price increases in the property sector. Unlike the early 1980's, when low real rates were contrasted by high nominal rates, the present low interest rate environment is characterised by relatively low inflation. The effect of low interest rates on mortgage repayments may be gleaned from Figure 3 (insert Figure 3 here), which plots average house prices and average monthly mortgage repayments. From the graph, while house prices between 1996 and 2002 have grown by almost 150 per cent, mortgage repayments for the same period have grown by just over 107 per cent - a considerable increase in its own regard. However by 2002, both indices have diverged significantly, illustrating just how much lower interest rates can sustain higher house prices. While mortgage repayments, clearly, have not increased to the same extent as house prices, they still have grown by a very large amount. The affordability of these higher repayment levels on an average income basis can be captured in Figure 4 (insert Figure 4 here), which plots the ratio of mortgage repayments to rental income (MRRI) and mortgage repayments to disposable incomes (MRDI) with both again expressed in index form. The picture presented in Figure 4 differs somewhat from that in Figure 1. It is evident that neither of these two ratios is above their historical highs. Mortgage repayments to rental income is above its historical average[3] by 15 per cent in 2002, while mortgage repayments to disposable income is actually over 9 per cent *below* its average rate for the sample. Allowing for the effect of the lower interest rate results in a more benign picture of the Irish property market in terms of the affordability of mortgage repayments and the relationship between this affordability and earning capacity. Relative to historical levels, it is evident that, Irish homeowners are not overburdened in terms of their mortgage repayments. This result is somewhat supported by recent empirical analysis by Kearns (2004), who concluded that, given the comparatively large growth in Irish mortgage lending over the 1995-2000 time period, it does not appear that the new mortgage lending has become more concentrated among householders with higher probabilities of arrears.

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[3] The average is in terms of the actual ratio and not the average of the ratio in index form.

All of these indicators are synonomous with demand-side considerations. The supply of housing is generally assumed to be sticky in its response to market price signals. In an Irish context, the Bacon report also outlined a variety of measures aimed at increasing the availability of residential property. These included offering preferential taxation rates for the release of land banks for residential developments and measures aimed at improving the infrastructure required for housing on land already zoned for residential purposes. Figure 5 (insert Figure 5 here) plots the number of both private and social housing units supplied per annum between 1980 and 2002. The rapid increase in private units post 1993 is evident, however, it still is obviously not of a sufficient magnitude to offset the increase in demand for the same period.

The next section introduces an empirical model of the Irish housing market.

3   An Empirical Model of the Irish Housing Sector

The theoretical model postulated for the Irish housing market is similar to that hypothesised by Duffy (2002), Bacon, MacCabe and Murphy (1998) and Kenny (1998). The model consists of a three equation system, which allows for the simultaneous interaction of both supply and demand and which implicitly acknowledges the stickiness of housing supply in response to price signals. The following list of variables are used in the analysis

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$$
\begin{aligned}
P &= \text{average house prices.} \\
U &= \text{real rental price.} \\
S &= \text{supply of housing.} \\
I &= \text{housing investment} = \text{P} \times \text{S.} \\
HC &= \text{housing stock } (H) \text{ per capita } (C). \\
YC &= \text{income } (Y) \text{ per capita.} \\
D &= \text{demographic variable - level of net migration.} \\
B &= \text{index of builders costs.} \\
F &= \text{land costs.} \\
\sigma &= \text{depreciation rate for housing.} \\
R &= \text{real interest rate} \\
G &= \text{average mortgage approved}
\end{aligned}
$$

The theoretical system is defined as follows, with the hypothesised sign preceding each variable

$$
P_t = f\left(+U_t, +YC_t, +D_t, +G_t, -HC_t, -R_t\right) \tag{1}
$$

$$
S_t = f\left(+P_t, -B_t/P_t, -F_t\right) \tag{2}
$$

$$
H_t = (1 - \sigma)H_{t-1} + I_t \tag{3}
$$

The first equation - an inverted demand function specifies house prices as a function of standard demand shifters: income per capita, a real rental price, a real interest rate and a variable which allows for the interaction between supply and demand - housing stock per capita. Two other variables are also added to this list. Instead of a standard demographic variable (i.e. a proportion of the population between 25 and 34), we follow Roche (2003) and use the level of net migration into the country. Net migration has changed considerably in recent years reflecting the large

influx of immigrants - net migration went from -2,000 in 1995 to over +40,000 in 2002. Enlargement of the EU coupled with strong domestic economic growth is likely to result in a continuation of this trend. We also follow Roche (2003) by including the average level of mortgages approved in the demand side. This figure has grown by almost 130 per cent in real terms between 1995 and 2003 highlighting the greater inclination of financial institutions to facillitate house purchasing. The housing supply function (2) states that the supply of housing responds to house prices, an index of building costs and an index of the cost of land used in building houses. The cost of such land as a proportion of house prices has risen considerably in recent years. The final equation assumes that the housing stock rolls out in a classical perpetual inventory method given investment and an annual rate of housing depreciation.

An issue, which arises with the inclusion of some of the fundamental variables is one of simultaneity or endogeneity of these variables in relation to house prices themselves. For instance, some of the growth in land costs or the level of credit offered to customers may, itself, be a function of house price movements. Therefore, any growth in house prices attributed to growth in these variables may be overstated by the extent to which the variables are influenced by house prices to start with. While Roche (2003) has explicitly examined this issue, it is one which merits further attention, if as accurate a characterisation of the fundamental price as possible, is to be achieved.

While most Irish applications of the model given by (1) - (3) have been on an annual basis, the present approach avails of the quarterly data set used to estimate the Irish macro model at the Central Bank. Details of this data can be found in McGuire, O'Donnell and Ryan (2002). Thus, given the increased observations[4], a short-run dynamic approach is adopted for the empirical applications, with the long-run relationships of (1) and (2) nested within error correction specifications. Useful information may then be observed concerning the speed of adjustment to deviations from long-run equilibrium price and housing supply levels.

Table 1 in the Appendix to the paper presents the results of unit root tests con-

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[4]The quarterly data set runs from 1980:1 to 1999:4. However it has been extended/extrapolated out to 2002:4 (92 observations) for present purposes.

ducted on the variables listed above.[5] Augmented dickey-fuller (ADF) test statistics reveal that the null hypothesis of a unit root cannot be rejected at even the 10 per cent level for most variables. VARs are specified for both house prices and housing supply. Two VARs are hypothesised for house prices. The first one is specified in terms of $(P_t, U_t, YC_t, HC_t, D_t, G_t)$. The Johansen (1988) and Johansen (1991) approach to cointegration testing within vector autoregressive modelling is adopted. Tables 2, 3 and 4 in the Appendix present the results. For the initial house price VAR (Table 2), both the λ_{max} and the λ_{trace} statistics suggest the presence of one co-integrating vector between the variables. The results are similar for the housing supply function (Table 4) with both tests again suggesting one co-integrating vector. Table 1 (insert Table 1 here) presents the results of the long-run equilibrium relationships derived from both VARs. As can be seen, all variables signs conform with *a priori* expectations except the real rental rate (U). One would expect a positive relationship between the real rental rate and house prices, however, the negative relationship obtained is, primarily, due to the dominance of capital gains contained in the definition.[6] As a result, a separate specification is hypothesised for the demand side, with an expression for the real interest rate R replacing U in both the long and short run. This long run relationship is also presented in Table 1 (as House Price (2)). The second house price equation results in the estimation of *a priori* signed parameters for all variables. The real interest rate variable has the expected negative coefficient along with the housing stock variable, while the income and demographic variable are positively signed. Note, that the effect of the income per capita variable under the second house price equation has a less elastic effect than that under the first long-run price equation (0.110 versus 0.244). The following error correction models for house prices and housing supply incorporating the long-run relationships are then estimated

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[5]All estimations are conducted in both Microfit 4.1 and WinRats-21 5.0.

[6]Roche (1999) experienced the same result.

$$\triangle P_t = \alpha_0 + \alpha_1 \left(ECT_{t-1}^P\right) + \alpha_2 \left(ECT_{t-1}^S\right) + \sum_{i=1}^{4} \alpha_{i+2} \triangle P_{t-i}$$

$$+ \sum_{i=0}^{4} \alpha_{i+6} \triangle (U \text{ or } R)_{t-i} + \sum_{i=0}^{4} \alpha_{i+10} \triangle HC_{t-i}$$

$$+ \sum_{i=0}^{4} \alpha_{i+14} \triangle D_{t-i} + \sum_{i=0}^{4} \alpha_{i+18} \triangle YC_{t-i}$$

$$+ \sum_{i=0}^{4} \alpha_{i+22} \triangle G_{t-i} + u_t^P$$

$$\text{(4)}$$

$$\triangle S_t = \beta_0 + \beta_1 \left(ECT_{t-1}^S\right) + \sum_{i=1}^{4} \beta_{i+1} \triangle S_{t-i} + \sum_{i=1}^{4} \beta_{i+5} \triangle P_{t-i} +$$

$$\sum_{i=0}^{4} \beta_{i+9} \triangle (B_{t-i}/P_{t-i}) + \sum_{i=0}^{4} \beta_{i+13} \triangle F_{t-i} + u_t^S \qquad \text{(5)}$$

where ECT is the error correction term. From (4) and (5), it is evident that both ECT terms are included in the short-run price equations. This is quite intuitive as it allows dis-equilibrium in the supply side of the market to impact on the price of housing. So, for example, a surplus of housing supply in excess of the long-run equilibrium level would, *a priori*, be expected to exert downward pressure on the rate of house price growth i.e. $\alpha_2 \leq 0$. Over the full sample, the assumed 'sticky' supply-side response is considered to be valid, however, the supply-side terms are included to allow for some effects of the recent increase in the amount of housing units constructed.

The estimated results of (4) and (5) are presented in Table 2 (insert Table 2 here). Two error correction models are estimated for house prices (House Price (1) and House Price (2)) and one for housing supply. In the two house price equations, both error correction terms are included in the final models. While neither supply-side error correction terms are significant at even the 10 per cent level, the included terms permit some short-run adjustment in prices to developments in land and building costs. Comparing models (1) and (2), it may be observed that both models have almost the same explanatory power (R^2 of 79 for model (1) versus an R^2

of 76 for model (2)) and both models are almost equally parsimonious (model (1)'s 9 parameters versus model (2)'s 10). Overall, however, the second model is slightly preferred, as all variables in model (2)'s long-run cointegrating relationship are correctly signed. Additionally, the null hypothesis of heteroscedastic errors for model (1) cannot be rejected at the 5 per cent level. Both changes in house price fitted values are plotted with the actual value for (4) in Figure 6 (insert Figure 6 here). From the graph, it may be observed that both equations capture all major turning points in the actual series in the period of occurrence. The housing supply equation performs quite well with the supply side error correction term being significant at the one per cent level and having the correct sign.

The fitted values from the long-run expression in (4) can be interputted as an estimate of PF given the evolution of variables identified as the determinants of the fundamental price. Figure 7 (insert Figure 7 here) compares the estimate of PF from the second house prices model with the actual price (PA). As can be seen, the fundamental price generally tracks the actual price and from 1996 it also broadly shows the same significant increase displayed by PA. Throughout 1998 and 1999, the actual price is in excess of the fundamental price suggesting a degree of overvaluation within the market i.e. the potential presence of a bubble. However, from late 2000 the actual price and the fundamental price are practically the same, denoting that the recent increases in house prices are almost fully explained by movements in the fundamental variables underpinning the market. Consequently, this result would appear to be in accordance with the plot of the average mortgage repayment to disposable income ratio in Figure 4. While house prices are undoubtedly high by historical levels, the combination of higher disposable incomes and lower interest rates means that the affordability of relatively higher mortgage repayments for Irish property owners is quite sustainable in the medium term.

In a recent contribution, Roche (2003) dispenses with the 'sticky' supply hypothesis and just estimates a reduced form long-run price equation, which directly incorporates supply-side considerations. This results in the following specification: $P = f(D, G, YC, R, F, B)$. A plot of actual values along with the fitted values from such a model are presented in Figure 8 (insert Figure 8 here).[7] The results would

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[7]Full regression results are available from the author upon request. Note Roche (2003) also includes a time trend to proxy for household formation.

appear to coincide with those reached in Figure 7 i.e. there is no apparent evidence of recent overvaluation in the housing sector.

3.1 Interest Rates Expectations

A particular criticism of the use of current mortgage rates in the system (1) to (3) is that present day interest rates are considered by many to be at the bottom of the interest rate cycle.[8] Figure 2 clearly illustrates the relatively low level of both nominal and real interest rates over the past 10 years in general and the last two years in particular. Thus, a question arises as to whether house purchasers are using present rates as their expected levels or some set of expectations which are more in line with longer-run, higher levels. If so, and individual agents expectations of interest rates are much higher than those based on present mortgage rates, then the affordability of present mortgage levels would be overstated to some extent.

While the use of a forward-looking expectations mechanism regarding interest rates is entirely plausible, from a consistency perspective, one could argue for the extension of such an approach to alternative variables such as disposable income. Most agents, after all, would expect a relatively linear increase in their income levels over the full schedule of a mortgage. Nonetheless, we focuss here on the case of longer-term interest rate expectations by substituting the interest rate on 10 year Irish Government bonds (L_t) for the mortgage rate (R_t) in the system (1) - (3). We estimate a new long-run relationship for the house price equation (House Price (3)) and compare the parameter results with those for House Price (2) in Table 1. Both sets of parameter results are in Table 3 (insert Table 3 here). From the table, it may be observed that, while most parameter sizes remain relatively unaffected by the change in the interest rates, the effects are relatively significant for the interest rate variable itself and the disposable income variable. The parameter size on the 10 year Government bond rate is exactly 50 per cent of that of the mortgage rate with the disposable income variable parameter increasing by almost 23 per cent under model (3). Clearly, therefore, there would appear to be some difference between the relative effects of both interest rates.

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[8] The Economic and Social Research Institute (ESRI), for example, forecast a gradual tightening of monetary policy throughout 2004. See McCoy, Duffy, Bergin and Cullen (2003) for more details.

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In order to test which interest rate is the more appropriate, a subsequent long-run equation is estimated which includes both interest rate variables. The equation is estimated with the autoregressive distributed lag (ARDL)[9] approach to cointegration in Microfit 4.1. Table 4 (insert Table 4 here) reports the estimated coefficients and their associated p-values based on asymptotic standard errors. Results are presented for both the Akaike Information (AIC) and Schwarz Bayesian Criterion (SBC).

The results are ambigious at best with the disposable income variable in particular having a counter-intuitive negative sign under both the AIC and SBC models. Neither interest rates are significant at even the 10 per cent level under both models. However, in both cases, the long-term interest rate L_t does have the expected negative sign, while the shorter term rate is positively signed. Thus, when both variables are included, the longer-term rate would appear to marginally prevail in a direct comparison.

If individual agents do use a relatively 'higher' interest rate than the actual mortgage rate, what implications does this have for the presence or otherwise of a bubble in the housing market? Figure 9 (insert Figure 9 here) plots the fundamental price from House Price (3) in Table 3 and the actual house price. From the graph, it is evident that the resultant fundamental price is practically the same as that estimated with the mortgage interest rate. Consequently, the use of a more longer-term interest rate to *proxy* for individual agent's interest rate expectations does not change the conclusions concerning the presence of a bubble in the Irish housing market.

4   Concluding Comments

Irish housing prices are indeed at historically dizzy heights. A property market crash analogous to that experienced in the UK in the late 1980's and early 1990's would indeed present considerable difficultues for the house owning public, the stability of the financial sector and the construction sector. The latter allied to the growth in personel consumption fuelled by increased wealth levels have been some of the main engines for growth in the Irish economy for the 1995-2000 time period. Initial

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[9]For more on this see Pesaran and Shin (1995).

inspection of the housing market would suggest that the actual price of houses has diverged to a worrying extent from the long run value of housing suggested by standard price-earning ratios. However, allowing for the lower interest rate environment of the late 1990's and early part of the new century suggests that long-run values are not out of kilter with the ability of the general public to sustain mortgage repayments.

Are Irish investors purchasing property on the premise of capital appreciation? The divergence between rental incomes and mortgage repayment levels (MRRI in Figure 4) would suggest so. However, the gap between actual and fitted house prices is non-existant by the end of the sample. This allied to the substantial improvement in market fundamentals indicates that Irish house prices, by the end of 2002, were in line with their long-run equilibrium values. Furthermore, affordability indicators incorporating lower interest rates reveal that Irish house owners, on a historical comparison, are comfortably coping with mortgage repayment levels at the end of the sample period. While there is some evidence to suggest that house purchasing agents appear to have higher interest rate expectations than current mortgage rates, the growth in house prices is still very much explained by fundamental factors.

However, a number of important considerations must be borne in mind at this point; firstly, one important caveat to the results presented here is the potential endogeneity of both land costs and the level of mortgages on offer from financial institutions. For instance, are lending institutions reacting to, or adding to the increases in housing demand by virtue of the increased credit on offer within the domestic mortgage sector? Similarly, increased land costs are increasing the cost of supply of housing, however is this increase in land costs, in itself, exogenous to the general level of house prices? Consequently, future research in this area could examine the extent to which these variables respond to, or, influence activity in, the housing market.

Secondly, merely because actual and fundamental prices are fairly closely aligned at present does not mean that the housing market is impervious to a serious correction in the future. Analysis has shown that house prices are very responsive to movements in disposable income (with very high income elasticities of demand); any diminution in the rate of income growth would have a depressing effect on house price growth or even the levels of prices themselves. Furthermore, Figure 3

has shown how mortgage repayment levels have grown much more slowly than the growth in house prices. Historically low interest rates have enabled house buyers to afford historically high prices. However, any persistent upward movements in interest rates will greatly affect this affordability placing resultant pressure on prices. Thus, the housing market is liable to be highly sensitive to any significant interest rate changes. Certainly, with interest rates at or near the low end of the cycle, further strong increases in house prices (double digit) would almost certainly result in overvaluation in the property market.

Finally, the supply of residential accommodation has been increasing significantly in recent years. This, along with further infrastructural improvements (improved transportation), is likely to dampen down the rate of house price increases in the years to come. In an equilibrium context, if a slowdown were to take place in terms of the other fundamental demand variables, the response of the construction sector would be very important vis-à-vis the resultant effect on price. If rigidities existed within the supply side to such a slowdown, i.e. if supply kept growing, then the decline in price could be exacerbated. On the other hand, a more flexible response or relatively sudden reduction in the number of housing units available, i.e. a response to weaken demand, would limit the decline in prices and ensure the absence of a particularly painful correction.

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Table 1: Long Run Housing Model Parameter Estimates

Variables	House Price (1)	House Price (2)	Housing Supply
INPT	2.241	3.387	-7.031
$ln\,P_t$	DN	DN	1.173
U_t	-0.103E-4		
$ln\,HC_t$	-0.493	-0.488	
D_t	0.002	0.002	
$ln\,YC_t$	0.244	0.110	
$ln\,G_t$	1.066	1.048	
R_t		-0.005	
$ln\,S_t$			DN
$ln\,(P_t/B_t)$			-0.269
F_t			-0.059

Note: ln denotes the natural logarithm of a variable, DN denotes dependent variable and 'INPT' denotes intercept.

Table 2: Error Correction Model Parameter Estimates and Diagnostic Tests

	House Price (1)	House Price (2)	Housing Supply
ECT^P_{t-1}	-0.138	-0.064	
	(-2.204)	(-2.429)	
ECT^S_{t-1}	-0.002E-3	-0.103E-3	-0.172
	(-0.206)	(-0.106)	(-2.036)
$\triangle R_t$		-0.004	
		(-8.760)	
$\triangle P_{t-1}$	0.275		
	(3.125)		
$\triangle G_t$	0.509	0.359	
	(5.076)	(3.088)	
$\triangle G_{t-1}$		0.550	
		(5.074)	
$\triangle \frac{B_{t-1}}{P_{t-1}}$			-0.557
			(-1.587)
$\triangle U_t$	-0.663E-5		
	(-9.874)		
$\triangle U_{t-1}$	-0.205E-5		
	(-2.897)		

Table 2: Error Correction Model (continued)

	House Price (1)	House Price (2)	Housing Supply
$\triangle S_{t-1}$			-0.386
			(-3.215)
$\triangle S_{t-2}$			-0.339
			(-2.762)
$\triangle S_{t-3}$			-0.269
			(-2.381)
$\triangle S_{t-4}$			0.344
			(3.396)
$\triangle YC_t$		-0.017	
		(-0.242)	
$\triangle D_{t-2}$	-0.001		
	(-1.975)		
$\triangle HC_t$		0.294	
		(2.029)	
$\triangle HC_{t-1}$		0.374	
		(2.679)	
$\triangle HC_{t-2}$	0.831	0.382	
	(5.803)	(0.382)	
$\triangle HC_{t-3}$	0.468	0.605	
	(3.508)	(3.763)	
R^2	0.79	0.77	0.54
AR	0.166	0.796	0.064
ARCH	0.038	0.717	0.051

Note: T-statistics are in parenthesis. ECT is the error correction term. All variables with the exception of $U_{t+i, i=0...3}$ are in logs. P-values are presented for serial correlation (AR) and heteroscedasticity (ARCH) tests.

Table 3: Comparison of Long-Run House Price
Equation Parameters with Mortgage and L/Run Interest Rates

Variables	House Price (2)	House Price (3)
INPT	3.387	2.948
$ln\ HC_t$	-0.488	-0.460
$ln\ D_t$	0.002	0.002
$ln\ YC_t$	0.110	0.144
G_t	1.048	1.040
R_t	-0.005	
L_t		-0.002

Note: ln denotes the natural logarithm of a variable and 'INPT' denotes intercept.

Table 4: ARDL Long-Run House Price
Equation with both Mortgage and L/Run Interest Rates

| | SBC | | AIC | |
Variables	Coefficient	P-Value	Coefficient	P-Value
$ln\ HC_t$	1.096	0.464	0.948	0.467
$ln\ D_t$	0.008	0.252	0.007	0.236
$ln\ YC_t$	-2.903	0.375	-2.704	0.349
G_t	2.0472	0.102	2.063	0.079
R_t	0.120	0.279	0.073	0.316
L_t	-0.072	0.417	-0.049	0.485

Note: ln denotes the natural logarithm of a variable. SBC = Schwarz Bayesian Criterion and AIC = Akaike Information Criterion.

Appendix A

The house prices used in this study are a combination of new and existing prices from various 'Housing Statistics Bulletins' of the Department of the Environment and Local Government. These are weighted by the ratio of loans paid on new and other houses which is also available in the same publication. Housing supply is the total number of housing completions (both private and local authority). This is also available in the Housing Statistics Bulletin as is the index of builders costs and G the value of loans approved. The demographic variable is available on an annual basis from the Central Statistics Office (CSO) and is interpolated for quarterly observations. The income variable and the deflator used are from the Irish macro-model database created and maintained in the Economic, Analysis Research and Publications Department (EARP) in the Central Bank. Details of the database and interpolation procedures used to compile it are available in McGuire, O'Donnell and Ryan (2002). The housing stock is derived both from the model database and a series of non-residential housing stock used in McQuinn (2003). The real rental rate U is defined as the following

$$U_t = [(\alpha \times L + (1 - \alpha) \times M) \times (1 - A) + (\sigma) + (T \times O)$$
$$- (P_t - P_{t-1})/P_{t-1}] \times P_t \qquad (6)$$

where

$$
\begin{aligned}
P &= \text{average house prices.} \\
\alpha &= \text{down-payment as a \% of purchase price.} \\
M &= \text{mortgage interest rate.} \\
L &= \text{long-term interest rate.} \\
A &= \text{average marginal tax rate.} \\
\sigma &= \text{depreciation rate.} \\
T &= \text{stamp duty rate.} \\
O &= \text{ratio of the value of old mortgages to total level of mortgages.}
\end{aligned}
$$

The M and L variables are also from the macro-model database while the ratio O is based on data available in the Housing Statistics Bulletin. Data on the level of land costs F is kindly provided by Dr. Maurice Roche (NUI Maynooth). The rent levels used in the calculation of the indices PR and MRRI are derived by applying the monthly private rental index under the CSO's consumer price index to a November 2002 rental income figure for West Dublin. The monthly mortgage repayment levels used in the indices MMR, MRRI and MRDI are calculated for a 90 per cent mortgage over 20 years at the mortgage interest rate M.

Table 1: Augmented Dickey Fuller (ADF)
Test Statistics Results for Housing Model Variables

| | | Critical Value | |
Variable	Test Statistic	1%	5%
P	1.571	-3.51	-3.17
U	-3.045	-3.51	-3.17
S	0.276	-3.51	-3.17
YC	2.112	-3.51	-3.17
D	-0.789	-3.51	-3.17
B/P	-3.245	-3.51	-3.17
F	0.256	-3.51	-3.17
HC	0.469	-3.51	-3.17
R	-1.602	-3.51	-3.17
L	1.597	-3.51	-3.17

Note: N = 92.

Table 2: Cointegration Likelihood Ratio
Test Statistics Results for House Prices VAR 1

| Null | Alternative | λ_{max} | λ_{trace} | Critical Value | |
				95%	90%
r = 0	r = 1	52.016		39.830	36.840
r<= 1	r = 2	27.821		33.640	31.020
r<= 2	r = 3	20.862		27.420	24.990
r<= 3	r = 4	9.773		21.120	19.020
r<= 4	r = 5	9.270		14.880	12.980
r<= 5	r = 6	0.405		8.070	6.500
r = 0	r>=1		120.146	95.870	91.400
r<=1	r>=2		68.130	70.490	66.230
r<=2	r>=3		40.309	48.880	45.700
r<=3	r>=4		19.448	31.540	28.780
r<=4	r>=5		9.6748	17.860	15.750
r<=5	r>=6		0.405	8.070	6.500

Note: N = 87, Order of the VAR = 4 based on AIC and SBC criterion. Cointegration test is with unrestricted intercept and no trends.

Table 3: Cointegration Likelihood Ratio
Test Statistics Results for House Prices VAR 2

| Null | Alternative | λ_{max} | λ_{trace} | Critical Value | |
				95%	90%
r = 0	r = 1	29.099		39.830	36.840
r<= 1	r = 2	26.249		33.640	31.020
r<= 2	r = 3	20.293		27.420	24.990
r<= 3	r = 4	13.368		21.120	19.020
r<= 4	r = 5	10.417		14.880	12.980
r<= 5	r = 6	0.005		8.070	6.500
r = 0	r>=1		99.432	95.870	91.400
r<=1	r>=2	70.333	70.490	66.230	
r<=2	r>=3		44.083	48.880	45.700
r<=3	r>=4		23.790	31.540	28.780
r<=4	r>=5		10.422	17.860	15.750
r<=5	r>=6		0.005	8.070	6.500

Note: N = 87, Order of the VAR = 4 based on AIC and SBC criterion. Cointegration test is with unrestricted intercept and no trends.

Table 4: Cointegration Likelihood Ratio
Test Statistics Results for Housing Supply VAR

Null	Alternative	λ_{max}	λ_{trace}	Critical Value	
				95%	90%
r = 0	r = 1	31.714		27.420	24.990
r<= 1	r = 2	19.380		21.120	19.020
r<= 2	r = 3	5.726		14.880	12.980
r<= 3	r = 4	0.757		8.070	6.500
r = 0	r>=1		57.577	48.800	45.700
r<=1	r>=2		25.863	31.540	28.780
r<=2	r>=3		6.483	17.860	15.750
r<=3	r>=4		0.757	8.070	6.500

Note: N = 87, Order of the VAR = 4 based on AIC and SBC criterion. Cointegration test is with unrestricted intercept and no trends.
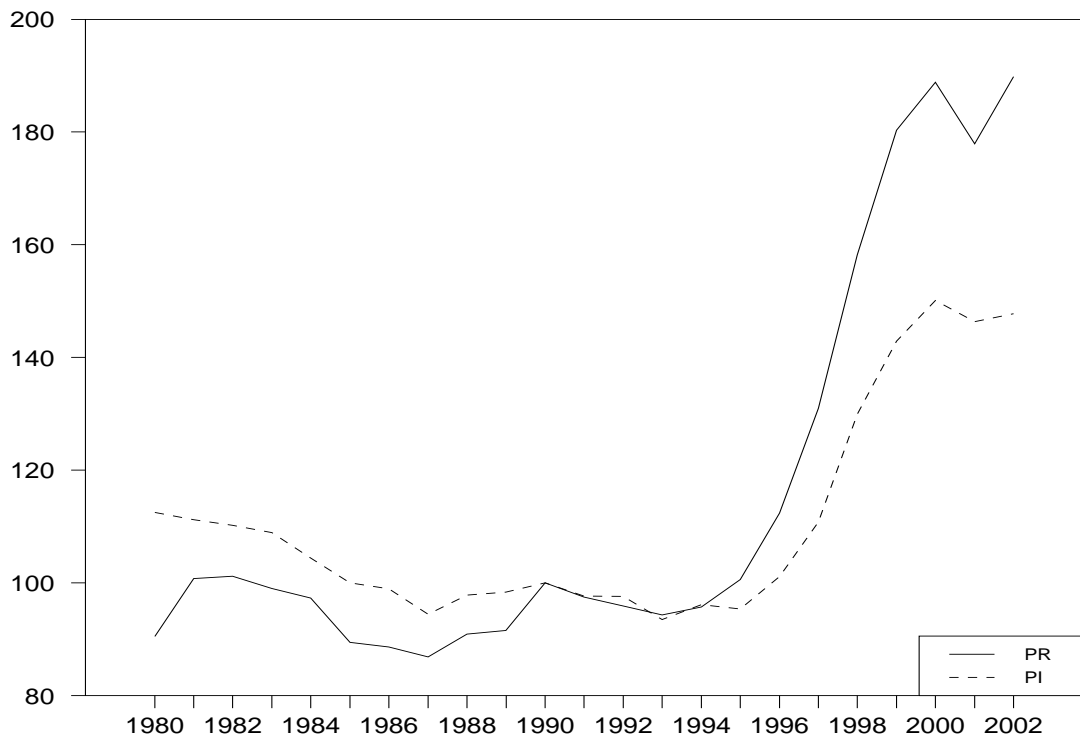
Figure 1: Price to Rent (PR) and Price to Income (PI) Index Ratios (1990=100) for the Irish Housing Sector: 1980-2002
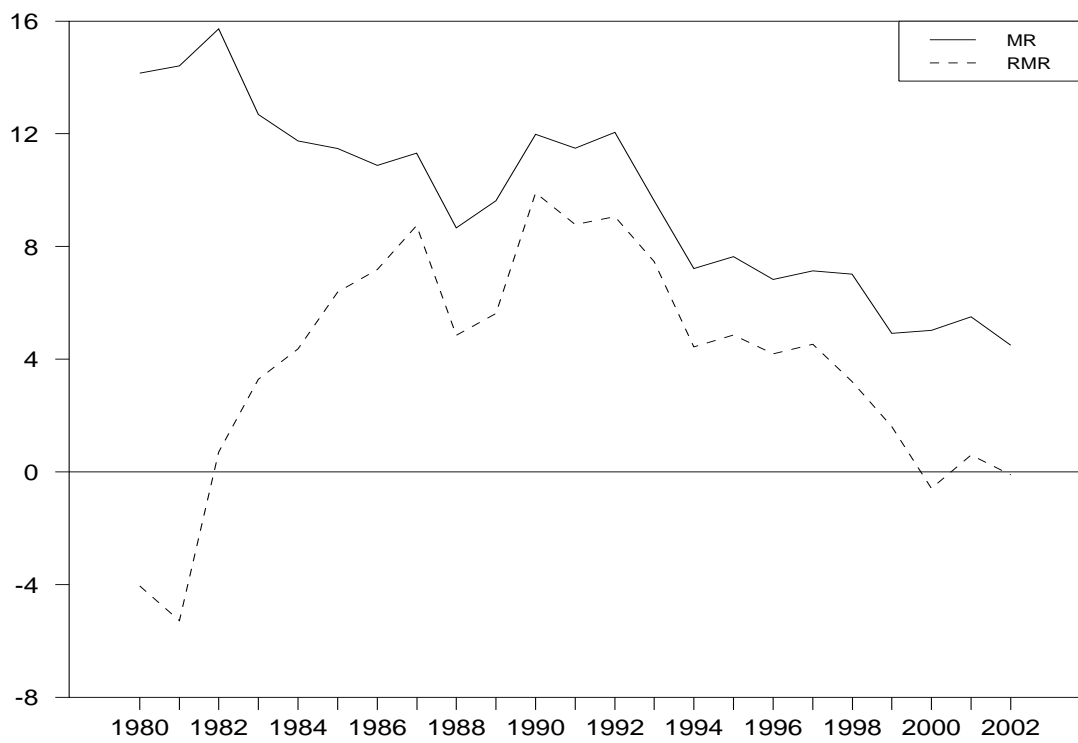
Figure 2: Nominal (MR) and Real (RMR) Irish Mortgage Rates (%): 1980-2002
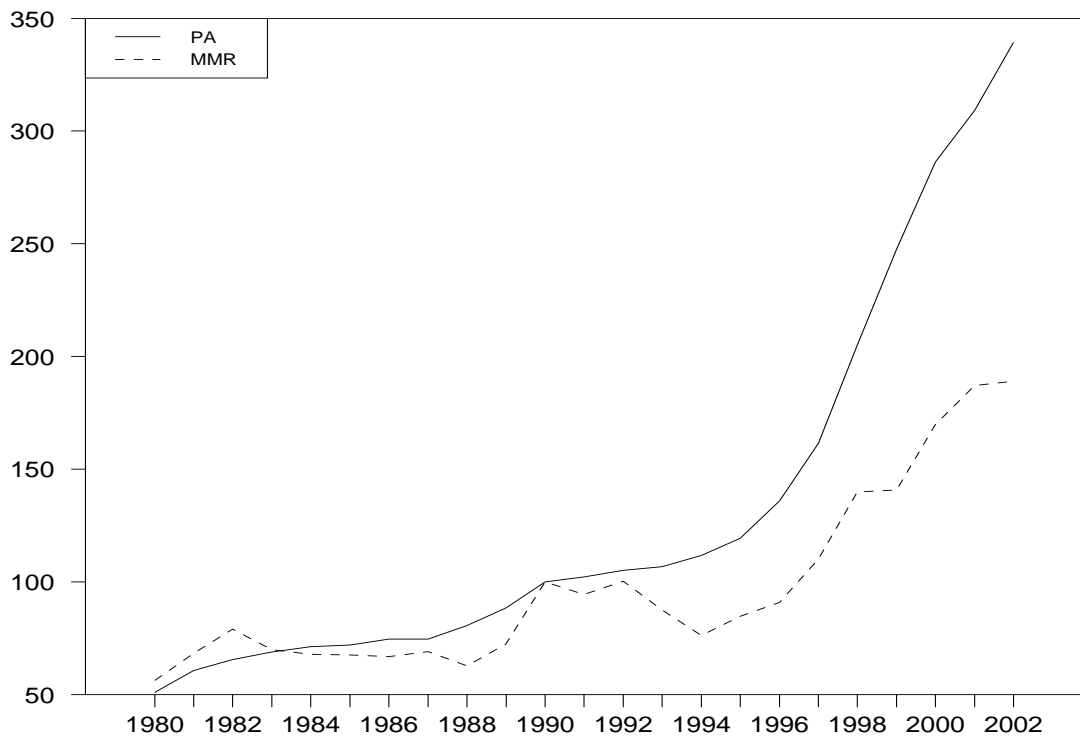
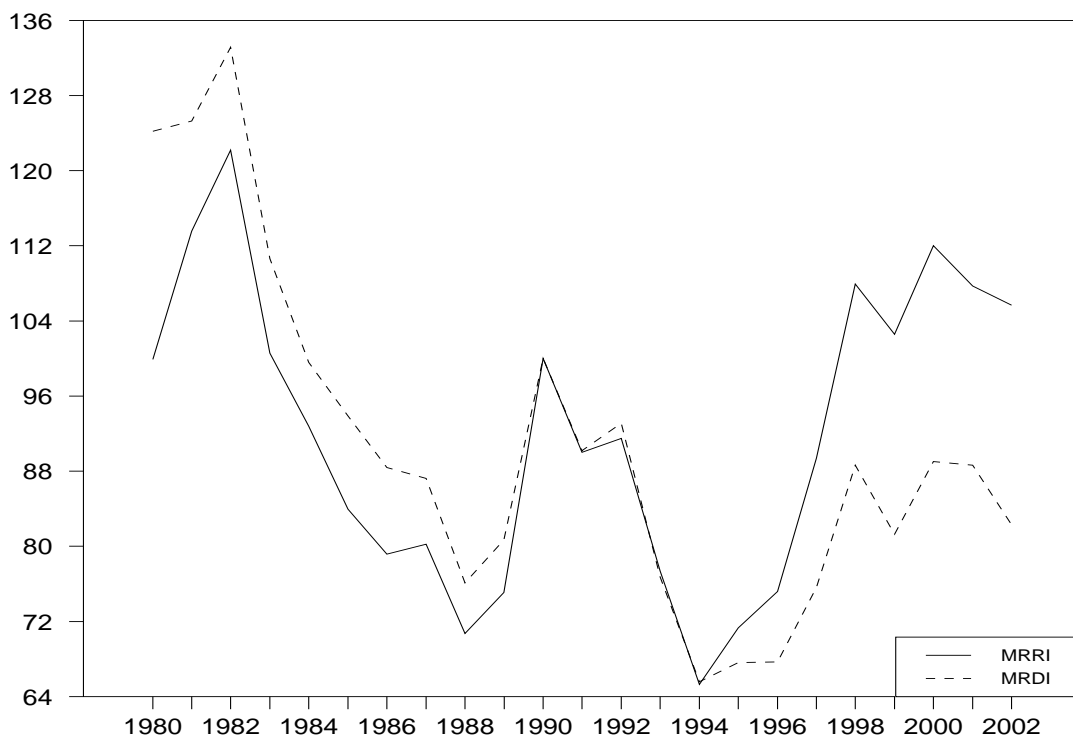Figure 3: Average House Price (PA) and Monthly Mortgage Repayments (MMR) Indices (1990=100): 1980-2002

Figure 4: Mortgage Repayments to Rental Income (MRRI) and Mortgage Repayments to Disposable Income (MRDI) Indices (1990=100): 1980-2002
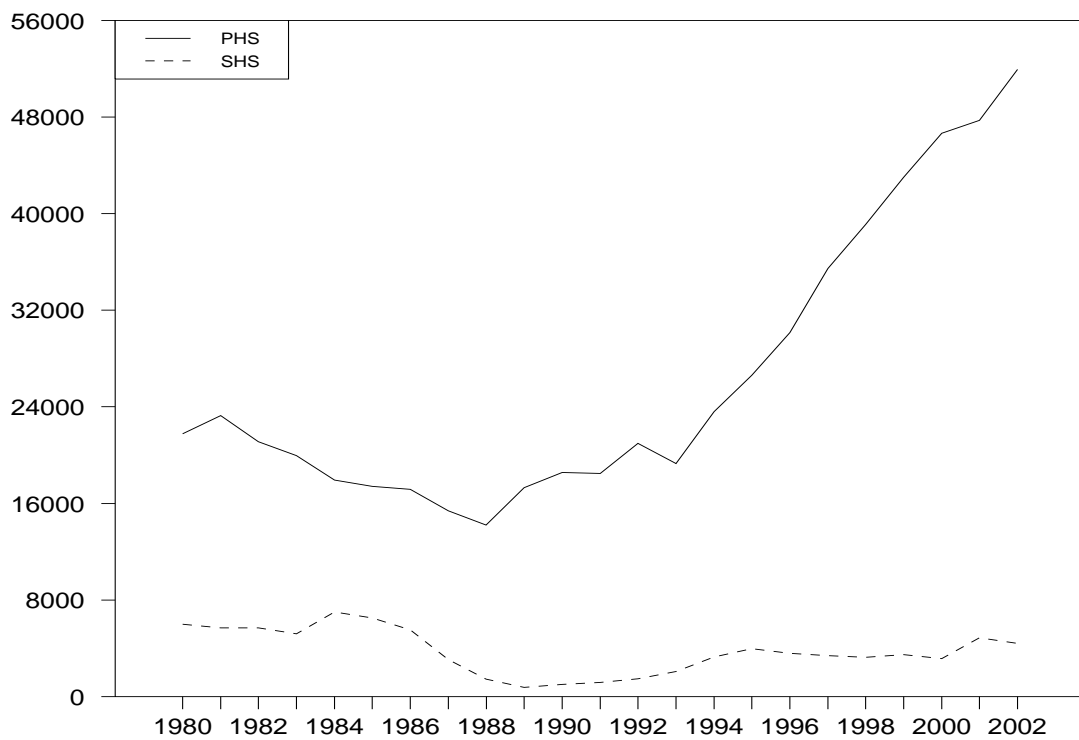
Figure 5: Supply of Private Housing (PHS) and Social Housing (SHS) Units (in levels): 1980-2002
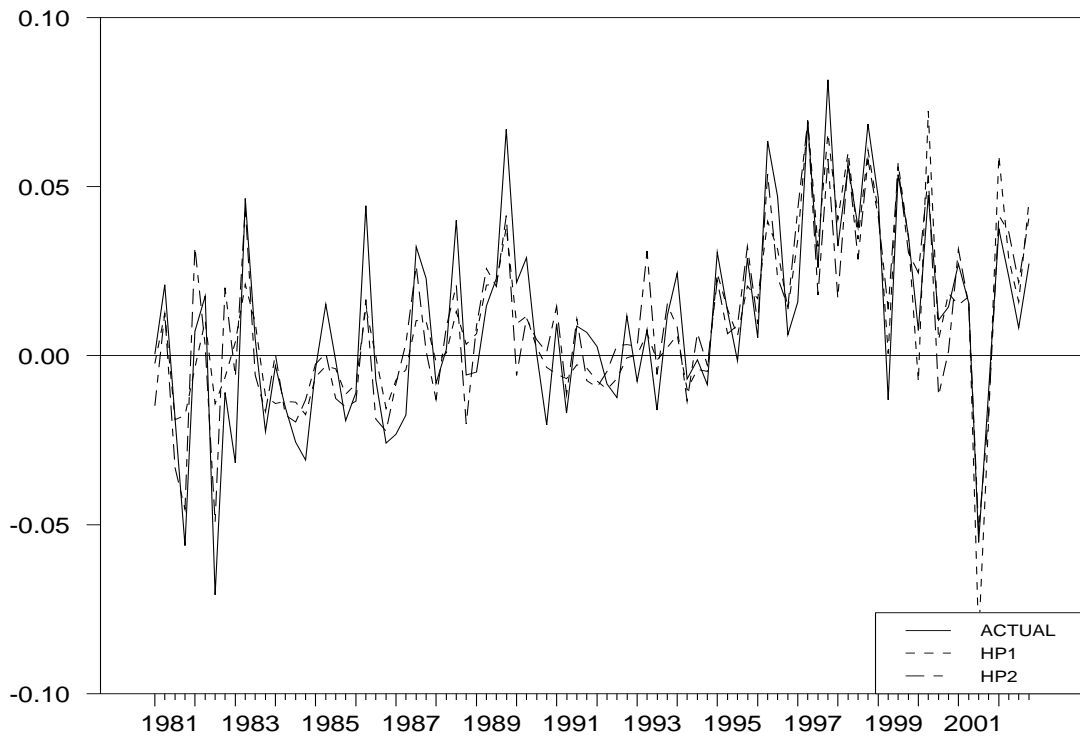
Figure 6: Plot of the Change in Actual House Prices (ACTUAL) and the Fitted Values from House Price Equation 1 (HP1) and House Price Equation 2 (HP2): 1981-2002
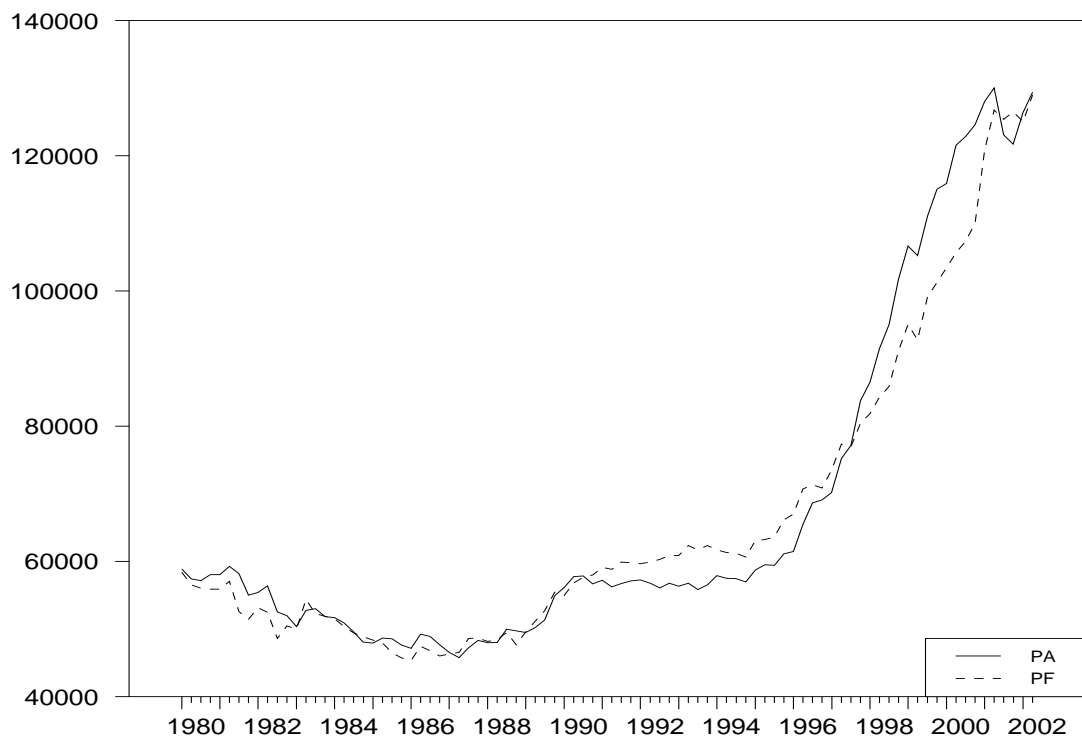
Figure 7: Plot of Actual House Prices (PA) and Fundamental House Prices (PF)
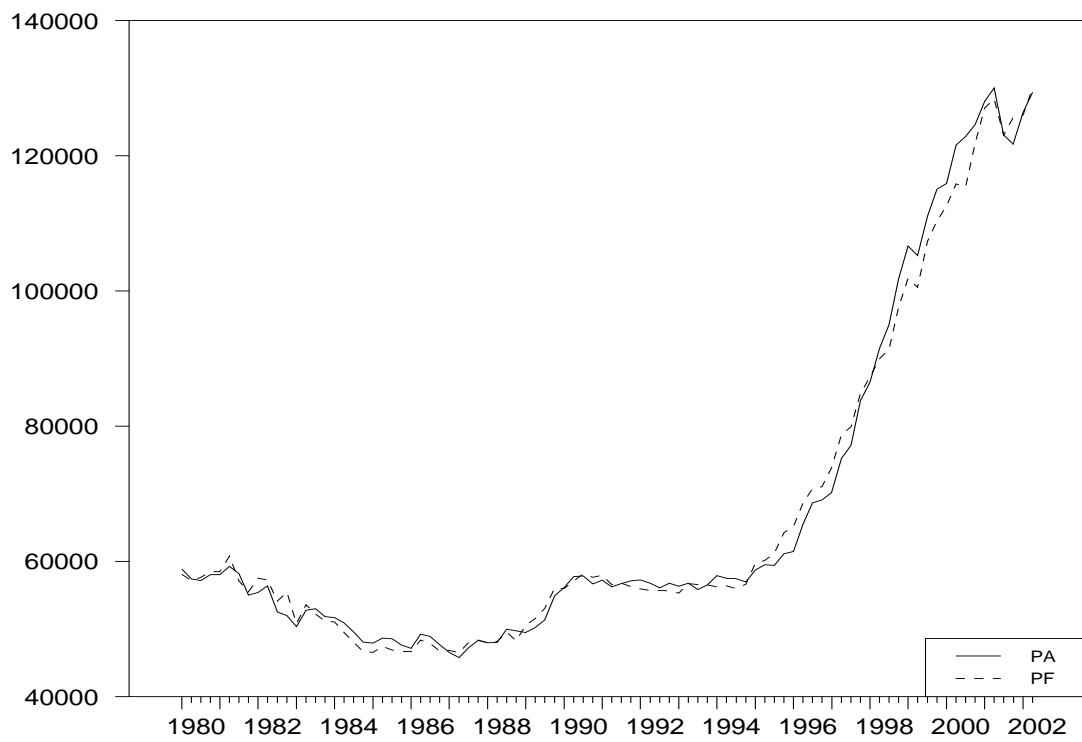(in €'s): 1980-2002

Figure 8: Plot of Actual House Prices (PA) and Fundamental House Prices (PF) (in €'s) using the Roche (2003) Approach: 1980-2002
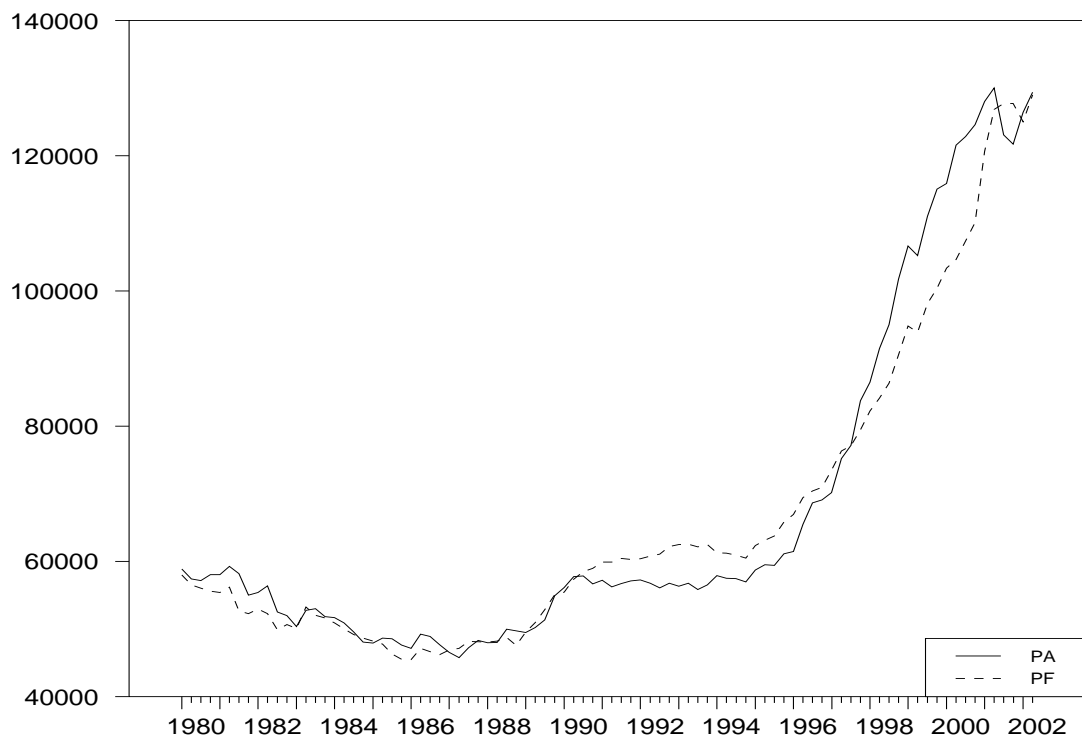
Figure 9: Plot of Actual House Prices (PA) and Fundamental House Prices (PF) (in €'s) using Long-Term Interest Rates: 1980-2002