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Research Technical Paper

Identifying and Forecasting House Price Dynamics in Ireland

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Abstract

While increased attention has, of late, focussed on models of house prices, few, if any, studies have examined house prices from a purely forecasting perspective. However, the need for accurate and timely forecasts of house prices has grown as the rate of house price inflation is more and more important to policy discussions such as those governing decisions on inflation. This is further underscored with the development of financial markets products based on house price index. In this paper, we propose that a simple univariate moving average (MA) model can provide optimal forecasts of Irish house price inflation when compared with a suite of standard forecasting and structural house price models. This result echoes similar recent findings for forecasts of US inflation rate.

Non Technical Summary

Over the past 5 to 10 years a variety of new and sophisticated quantitative approaches have been employed to model general inflation rates. These approaches mainly involve the use of factor analysis, where common trends are extracted from large quantities of data and then used to forecast the series in question. To date, much of this work has focussed on forecasting US inflation rates. The accuracy of these results have been compared with the results of more standard applications such as autoregressive and moving average models. Rather surprisingly, in many instances, the more sophisticated approaches have struggled to improve on the performance of the more traditional models. Many reasons have been advanced for these findings.

In this paper we forecast Irish house price inflation using some of these models and examine the performance of the models relative to the more standard approaches. Irish house price inflation would appear to be a logical avenue for examination in this regard for two reasons. Firstly, it would be interesting to see whether the results achieved for general rates of inflation would also hold for that of an individual commodity such as housing and secondly, Irish house price inflation was to the fore of the recent international surge in house prices. Consequently, achieving a timely and accurate model of housing inflation is increasingly of interest to policy makers.

Our results suggest that the change in Irish house price inflation can be best captured by an MA or moving average model. The IMA model is equivalent to an unobservable components model. In this case, inflation is allowed to have a time-varying mean. Therefore, an MA process is well equiped to capture the dynamics of a series, which is experiencing constant increases such as that experienced by Irish housing inflation over much of the sample period examined.

1 Introduction

The growth in the relative importance of international house price movements poses significant challenges for macroeconomic policy-makers. Most OECD countries have witnessed substantial increases in house prices over the past 10 years. *The Economist* estimated that house prices in such countries increased by a value of 30 trillion dollars over the period 2000-2005. This amounted to an increase equivalent to 100 per cent of those countries combined GDPs. This substantial increase in the value of residential property now means that significant variations in the price of houses has the potential to impact on many aspects of economic life.

In many instances, the growth in house prices has outstripped that of other key macroeconomic variables. For example, over the 10 year period 1997 to 2006, for a sample of OECD countries, the annual rate of house price inflation was nearly 4 times the equivalent increase in the consumer price index, whereas for the 10 year period preceeding this (1987-1996) the corresponding figure was 1.2.[1] As a result, house prices are increasingly becoming central to discussions on inflation.

Given the key role of house prices in the economy it is not surprising that financial markets have recently developed products based on developments in the housing market. In 2006, the Chicago Mercantile Exchange started offering futures and options contracts based on house price indexes developed by S&P/Case-Shiller for 10 US cities as well as an aggregate index. In March 2007, Delta Index a spread betting firm located in Dubliin announced the launch of spread betting based on the monthly level of the ERSI/permanent tsb house price survey.

Based on these considerations policymakers and market participants clearly require a timely and accurate forecasts of house price inflation. This paper seeks to present such a model. In particular, we propose that Irish house price inflation over the period 1980 to 2006 can be represented by a parsimonious univariate model, or, more specifically a first order integrated moving average (IMA(1,1)) model. As such, the approach builds on existing work by Stock and Watson (2005) and (2006) who apply a similiar approach to modelling inflation rates.

[1] Authors own calculations. The countries included are the US, France, Italy, the United Kingdom, Canada, Australia, Denmark, Spain, Finland, Ireland, the Netherlands, Norway, New Zealand, Sweden and Switzerland.

In modelling US inflation, Stock and Watson (2005) and (2006) have found that, since the mid 1980s, standard multivariate forecasting models such as the backwards-looking Phillips curve have performed relatively poorly vis-à-vis a univariate benckmark. While inflation series have undoubtably become less volatile since the late 1970s, it appears the ability of more sophisticated modelling approaches to outperform standard naive forecasts is somewhat open to question.

The Irish property market has been to the forefront of the rise in international house prices. Over the period 1995 - 2006, prices for new Irish houses rose by almost 300 per cent. However, this performance must be seen in the context of the exceptional performance of the Irish economy over the same period. The emergence of the Celtic Tiger in the 1990s has seen significant increases in many macroeconomic variables such as disposable income, employment levels and demographic factors, while monetary conditions have been characterised by a low and stable interest rate environment. *A Priori*, one would expect that any successful forecasting model of house prices would need to take cognisance of these changes.

The rest of the paper is organised as follows; in the next section we present a brief overview of the Irish housing market, focussing, in particular, on the dynamics of Irish house price inflation. We then outline the various models employed in the forecasting exercise before comparing the results of the different empirical applications. A final section offers some concluding comments.

2 The Irish Housing Market

Between 1980 to 2006 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 has led to a sustained economic boom. Between 1995 and 2006, the size of the economy doubled with the total number of people employed in the country increasing by almost 50 per cent. The transformation in economic conditions has gone hand in hand with profound change in the Irish housing market. For example, Irish house prices have between 1995 and 2006 averaged an annual increase of over 13 per cent. This average annual increase is the largest across an 18 country sample of OECD countries for the period.[2]

The length and size of the house price increase has, as might be expected, 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), Murphy (2004), Fitzpatrick and McQuinn (2007), Duffy, Fitzgerald and Kearney (2005) and McQuinn and O'Reilly (2007). Most of these models are concerned with estimating a "fundamental" price of housing i.e. the level of house prices suggested by variables considered to be fundamental determinants of the housing market. Typically these variables include interest rates, income levels and demographic variables. Once the fundamental price is determined, potential over/undervaluation in the market can be gauged by comparing this estimated price with the actual level.

However, few if any of these studies have evaluated, in any detail, the forecasting performance of the models concerned. Most empirical work is conducted over the entire sample available and very little recursive style estimation is performed. This latter point is particularly important as parameter stability is likely to be an issue given the rapid change in Irish economic conditions over the sample period. In our application, estimation of the various forecasting models is conducted over a moving sample period commencing with the initial period 1980 quarter 1 to 1989 quarter 4 and updating the estimation subsequently with additional data points until the end of the sample (2006 quarter 4).

2.1 Specific Features of Irish House Price Inflation

The nature of Irish house price movements is examined in greater detail in this section. Figure 1 plots nominal and real Irish house price inflation over the period 1980 to 2006. It is evident from this figure, that the Irish market has experienced two periods of significant growth. The first being in the late 1980s with the second being the present post 1995 boom. The rise in international interest rates in the early 1990s undoubtably served to "cool" the Irish market for a period of time,

[2] This sample consisted of US, France, Italy, the United Kingdom, Canada, Australia, Denmark, Spain, Finland, Ireland, the Netherlands, Norway, New Zealand, Sweden, Switzerland, Japan, Germany and South Korea.

however, the emergence of the Celtic Tiger post 1995 coupled with a more stable and benign monetary climate sparked a sustained period of price inflation. The one downturn in the post 1995 period (late 2001 into early 2002) is often attributed to a combination of both domestic policy and international events.[3]

First, we will proceed with a standard Box Jenkins type analysis of the properties of the house price series p_t.[4] The house price series used is new Irish house prices[5] and is available on a quarterly basis from the Irish Department of the Environment.[6] Analysis of the series in Figure 1 coupled with standard unit root tests suggest that house price inflation itself, ($\pi_t = \Delta p_t$), has a unit root. Thus, price levels are said to be $I(2)$.[7] In Figure 2, the auto and partial correlation functions of the rate of change of house price inflation $\Delta\pi_t$ are plotted. Both functions suggest that, on an *a priori* basis, the rate of Irish house price inflation follows a moving average process. Observe, in particular, the rapid decline in values of the autocorrelation function while the partial function witnesses a more gradual fall off. Both of these results are highly indicative of an MA(1) process.

2.2 A Note on the Data

As part of the forecasting exercise, a total of 19 different variables are used. These variables are listed in the Appendix to the paper along with their source. Most of the variables such as wholesale price indices and indices of industrial production are taken from the Irish Central Statistical Office (CSO), however other variables are drawn from a macroeconomic database maintained at the CBFSAI. Interest and exchange rates are taken from the IMF's International Financial Statistics (IFS) database. All data are quarterly and cover the period 1980 quarter 1 to 2006 quarter 4.

[3]The latter being global uncertainty in international markets following the events of September 11, while domestically the Irish government introduced measures specifically targetting investors in the Irish property market. These measures were subsequently withdrawn approximately a year after their introduction.

[4]The lower case denotes logs.

[5]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.

[6]Available at:
http://www.environ.ie/en/Publications/StatisticsandRegularPublications/HousingStatistics/

[7]Full unit root test results are available, upon request, from the authors.

In the next section, we empirically assess the forecasting performance of this univariate charachertisation of house price inflation by comparing the forecasts of a set of standard time-series models against this benchmark model.

3 The Forecasting Exercise

Our objective in modelling house price inflation is to predict the h-period house price inflation $\pi^h_{t+h} = \frac{400}{h} log(\frac{P_{t+h}}{P_t})$, where P_{t+h} is the real housing price inflation at time $t + h$. We employ a suite of five standard forecasting models typically used in the literature. The first model, based on our Box Jenkins analysis, is the benchmark model and the performance of all subsequent models is evaluated vis-à-vis the results of this model. The different models used are summarised as follows:

3.1 Forecasting Models

- **Integrated moving average (IMA(1,1)) (benchmark)**
  Based on the Box Jenkins analysis, house price inflation is modelled as being integrated of order one with a a moving average component (which is equivalent to an unobserved component model)

$$\pi_t - \pi_{t-1} = (1 - \theta L)\varepsilon_t \tag{1}$$

  The forecasts in this instance are recovered as: $\hat{\pi}^{h,ma}_{t+h|t} = \pi_t - \hat{\theta}\varepsilon_t$

- **Autoregressive model (AR)**

  Our second model is the standard autoregressive approach where

$$\hat{\pi}^h_{t+h|t} - \pi_t = c^h + \alpha(L)^h \Delta\pi_t + u^h_{t+h} \tag{2}$$

  forecasts of $\pi^h_{t+h|t}$, at time t, are computed as: $\hat{\pi}^{h,ar}_{t+h|t} = \pi_t + \hat{c}^h + \hat{\alpha}(L)^h \Delta\pi_t$ and *hat* denotes the estimated parameters.

- **Atkeson-Ohanian (AO)**:
  A further univariate approach used is the forecasting model of Atkeson and

Ohanian (2001). In modelling US inflation, Atkeson and Ohanian (2001) demonstrate that, since 1984, structural models of inflation have been outperformed by a naive forecasts based on the average rate of inflation over the previous 12 months. In this case, therefore, forecasts of housing prices inflation at times $t+h$ are computed as the average inflation of the four previous periods. This is essentially a "no change" forecast for inflation

$$\hat{\pi}_{t+h|t}^{h,ao} = \pi_t^4 = \frac{1}{4}(\pi_t + \pi_{t-1} + \pi_{t-2} + \pi_{t-3}) \tag{3}$$

- **Pooled forecasts (POOL)**

  While the first three forecast models are univariate in nature, we also generate forecasts based on a series of different regressors. The pooled forecast draws on the forecasting ability of a number of macroeconomic variables typically used in forecasting. In particular, we adopt 19 different variables and generate forecasts of house price inflation based on each of the 19 variables. The pooled forecast then takes the mean of the 19 forecasts as the final output. Each individual forecast is based on an Augmented Distributed Lag (ADL) model.

  Thus, inflation forecasts are generated based on the following ADL model including 19 alternative candidate predictors x_j $j = 1, ...n$ through the following equation:

$$\pi_{t+h|t}^{h} - \pi_t = \eta_j^h + \gamma_j^h(L)\pi_t + \delta_j^h(L)x_{t,j} + e_{t+h,j}^h \tag{4}$$

  and the pooled forecasts are computed as $\hat{\pi}_{t+h|t}^{h,pool} = \frac{1}{n}\sum_{j=1}^{n} \hat{\pi}_{t+h|t}^{h,adl(j)}$ where $\hat{\pi}_{t+h|t}^{h,adl(j)} = \hat{\eta}^{h,j} + \hat{\gamma}^{h,j}(L)\pi_t + \hat{\delta}^{h,j}(L)x_{t,j}$

- **Factor forecasts (F)**

  The final method used to model house price inflation is the factor based approach. A series of common factors are identified based on the 19 macroeconomic variables listed in the Appendix. Formally, forecasts of house price inflation are generated using the following projection equation

$$\pi_{t+h|t}^{h} - \pi_t = \tau^h + \beta^h(L)\pi_{i,t} + \lambda^h \hat{F}_t + \nu_{t+h}^h \tag{5}$$

where the common factors $\hat{F}_t$ are the first r sample principal components of $W_t = (w_{1,t}, ..., w_{n,t})', t = t_0, ..., t_1$ (the time span), where $w_{it} = \frac{x_{it}-\hat{\mu}_i}{\hat{\sigma}_i}$, and $\hat{\mu}_i$ and $\hat{\sigma}_i$ are the sample mean and standard deviation respectively. Specifically, $\hat{F}_t = \hat{\mathcal{V}}'W_t$, where $\hat{\mathcal{V}}$ is the $(n \times r)$ matrix of eigenvectors associated with the first r eigenvalues of $S = \frac{1}{t_1 - t_1 + 1}\sum_{t=t_0}^{t_1} W_t W_t'$.

The forecasts of house price inflation are then computed as:

$$\hat{\pi}^h_{t+h|t} = \hat{\tau}^h + \hat{\beta}^h(L)\pi_{i,t} + \hat{\lambda}^h \hat{F}_T \tag{6}$$

3.2 The Out-of-Sample Simulation

Having identified the IMA model as the benchmark, we now test if the alternative models for house price inflation can actually improve upon the IMA performance. To formally test this, we perform a pseudo out-of-sample forecast.

The procedure is as follows; the exercise begins by estimating (2) on a sub-sample called the estimation window (1980:Q1 to 1989:Q4) and for a given horizon $h = 1, ..., 4$. The estimated parameters are then used to forecast house price inflation h-steps ahead outside the estimation window. The estimation window is updated sequentially with one observation and the parameters are re-estimated based on the new sub-sample. The h-steps ahead forecasts are again computed outside the new sample. This procedure is then iterated until the end of the sample.

Upon completion, forecasts of π^h_{t+h}, labelled as $\hat{\pi}^{h,ima}_{t+h|t}$ are stored and used to compute the Mean Square Forecast Error ($MSFE$) for the forecast horizon h. For the benchmark model, the $MSFE$ is defined as the following:

$$MSFE_{h,ima} = \frac{1}{(t_1 - (t_0 + h))} \sum_{t=t_0+h}^{t_1} (\pi^h_t - \hat{\pi}^h_{t,ima})^2$$

The $MSFE$ is a measure of the average forecast accuracy over the out-of-sample window $t_0 = (1989 : Q1 + h)$ - $t_1 = (2006 : Q2 - 4 + h)$. The absolute values for the $MSFE$ for the benchmark model are reported in the first row of Table 2. Results are included over the forecast horizon $h = 1, ..., 4$.[8]

[8] For all of the models, we use the Bayesian Information Criterion (BIC) to determine the optimal lag length. The upper lag length chosen is 4 lags and the maximum number of factors is also 4.

The simulation exercise is then repeated exactly the same way for the other forecast models. The forecasts of these alternative specifications are stored and used to compute the $MSFE$ statistics defined as:

$$MSFE_{h,i} = \frac{1}{(t_0 - t_1 + a)} \sum_{t=t_0+h}^{t_1} (\pi_t^h - \hat{\pi}_{t,i}^h)^2$$

where $i \in (AR, AO, POOL, F)$.

To facilitate the comparison the results are given in terms of relative $MSFE$ statistic, defined as:

$$\frac{MSFE_{h,i}}{MSFE_{h,ima}}$$

When the relative MSFE is less than unity, a particular model improves the forecast precision of the benchmark model. For example, a value of 0.8 for model i indicates that the model improves the forecast performance of the benchmark model by 20%. The relative performance of the other four forecasting models are presented in rows 2 through 5 of Table 2.

4 Results

The results of the forecast exercise are presented in Table 2. The first row of the table reports the actual MSFE statistics, over the horizons 1 to 4, for the IMS(1,1) benchmark model. Rows two through five report the ratio between the MSFE of the alternative models to that of the benchmark specification.

Overall, it would appear from the table that the IMA(1,1) model is the most accurate from a forecasting perspective with ratio values greater than one for the non-benchmark models indicating a sub-optimal performance. The closest model in terms of forecasting performance is the AO specification. Particularly remarkable is the poor performance of the multivariate specifications. This suggests, therefore, that increasing the information set available by including other variables in the modelling exercise does not additionally help to explain the future dynamics of the house price series.[9]

[9] As well as the multivariate time-series approaches, we also examine the relative forecast per-

The result that house price inflation can be best approximated by an integrated MA process is very much in line with results achieved for US inflation by Stock and watson (2005, 2006). As they point out, in principal, the performance of the MA specification should be similar to the performance achieved with an AR model,[10] but this is not the case either for US inflation or for Irish house price inflation. The reasons for the disparity between the two models results may be due to the fact that an AR specification with a long lag length may result in an increased estimation variance[11] and secondly a large IMA parameter (θ in equation (1)) implies a larger autoregressive coefficients, which, in turn, leads to a more sever bias towards 0. In our application, the estimates of the MA parameters in the out of sample simulation exercise are around -0.9.

To get an understanding of the MA models performance over time, in Figure 3, we plot the forecasts of the benchmark MA model for 1, 2, 3 and 4 period ahead forecast horizons. The forecasts start in 1990 and are compared with the actual growth rates. From the figure, it is evident that, over the entire forecast period, the results from the MA model display a degree of smoothedness and appear to pick up, quite well, the underlying mean of the actual data. This is, particularly, the case when compared with the forecasts of the other modelling approaches.[12]

What can explain the forecasting primacy of the MA approach? Namely, that in the light of sophisticated multivariate forecasting options, a relatively naive forecasting model offers the best way to forecast Irish house price inflation. Inevitably, given the sustained sharp rise in Irish house prices since the mid 1990's, an IMA process is likely to track a series, which experiences consistent increases, quite well. To better understand this, recall that the IMA model is equivalent to an unobserv-

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formance of a reduced form model of house prices. For the purposes of this exercise, we use, as the reduced form approach, the model estimated by Murphy (2004) which regards itself as a "standard or textbook model of the housing market". House prices are regressed on income, the level of the housing stock, mortgage rates, a user cost of capital expression and a demographic variable denoting the share of the population in the 25 to 34 age bracket. However, the model performs very poorly in the forecasting performance. The results are available upon request. One reason for the poor forecasting performance of the reduced form model may be due to the relatively short sample analysed in the exercise - a longer sample might be more suitable for such a model.

[10]An MA model can be well approximated by an AR specification with many lags.

[11]In the exercise, we use four lags for the AR model, increasing the number of lags does not improve the forecasting performance, which in many cases worsens.

[12]These other graphical comparisons can be obtained, upon request, from the authors.

able components model, in which inflation has a time-varying mean. Therefore, such a model can well characterise the recent path of Irish house price inflation. The period (1995 to the present) constitutes the "Celtic Tiger" era, when most key Irish macroeconomic variables witnessed substantial increases. A future potential application of this approach could examine the performance of the competing forecasting models in a housing market, which has not experienced change on such a considerable scale.

5 Concluding Comments

The recent surge in property prices across countries has prompted considerable interest in models of housing markets. Much of this increased attention has concerned itself with approximating the fundamental price of housing. Namely; estimating the price level, which is justified by the levels of key economic variables in the market. The concern of this paper is somewhat different. We seek to establish an optimal forecasting model of house price inflation. The need for such a model is evidenced by the increasing emphasis placed on house price movements in the context of key policy decisions such as those governing inflation and, also, the emergence of financial products specifically targetting house price movements.

Our approach is similar to recent exercises aimed at modelling US inflation by Stock and Watson (2005) and (2006). Interestingly, some of the key results established by Stock and Watson for general inflation appear to pertain to the rate of house price growth. In particular, when evaluated vis-à-vis a suite of popular forecasting models, we find that Irish house price inflation can be best approximated by a parsimonious univariate model i.e. a first order integrated moving average (IMA(1,1)) model. Using standard time-series indicators of performance, we find that forecasts generated by an MA model consistently better those of the alternative forecasts.

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Table 1: Macroeconomic Data used in Multivariate Models

Description	Transformation	Source
Real Variables		
Real Gross Domestic Output	2	CBFSAI
Disposable Income	2	CBFSAI
Industrial Production, Seas. Adj.	2	CSO
Industrial Production Producing Intermediate Products	2	CSO
Industrial Production Mining and Quarrying	2	CSO
Industrial Production Manufacturing Employment	2	CSO
Asset Prices		
Residential mortgage interest rate	1	IMF
Government 10 year bond yields	1	IMF
Government 5 year bond yields	1	IMF
Nominal Effective Exchange Rate	2	IMF
Share Prices	2	IMF
Prices and Wages		
(Real) Price of New Irish Houses,	3	Irish DOE
Wholesale Prices Index,	3	CSO
Consumer Prices Index,	3	CSO
Wages: Weekly Earnings,	3	CSO
Manufacturing Price Index	2	CSO
Private/Personal Consumption Deflator,	3	CSO
Housing		
Residential mortgage lending	1	CBFSAI
CSO Residential Rental index	2	CSO
CSO Value of total loans approved	2	Irish DOE
CSO Number of total loans approved	2	Irish DOE

Note: The order of the transformation is as follows:
1: $X_{it} = \Delta Z_{it}$ is monthly difference
2: $X_{it} = \Delta \ln Z_{it} \times 400$ is monthly growth rate, and
3: $X_{it} = \Delta \ln \frac{Z_{it}}{Z_{it-1}} \times 400$ is second differences

For the sources, CBFSAI refers to a macroeconomic model database maintained at the CBFSAI, CSO is the Irish Central Statistical Agency, DOE is the Irish Department of the Environment and IMF is the IMF International Financial Statistics database.

Table 2:

	Horizon			
Models	***1***	***2***	***3***	***4***
IMA(1,1)	98.42	53.11	36.09	32.90
AR	1.21	1.21	1.17	1.12
AO	1.03	1.08	1.01	0.99
POOl	1.19	1.19	1.14	1.12
F	1.16	1.21	1.16	1.15

Figure 1: Nominal and Real Irish House Price Inflation

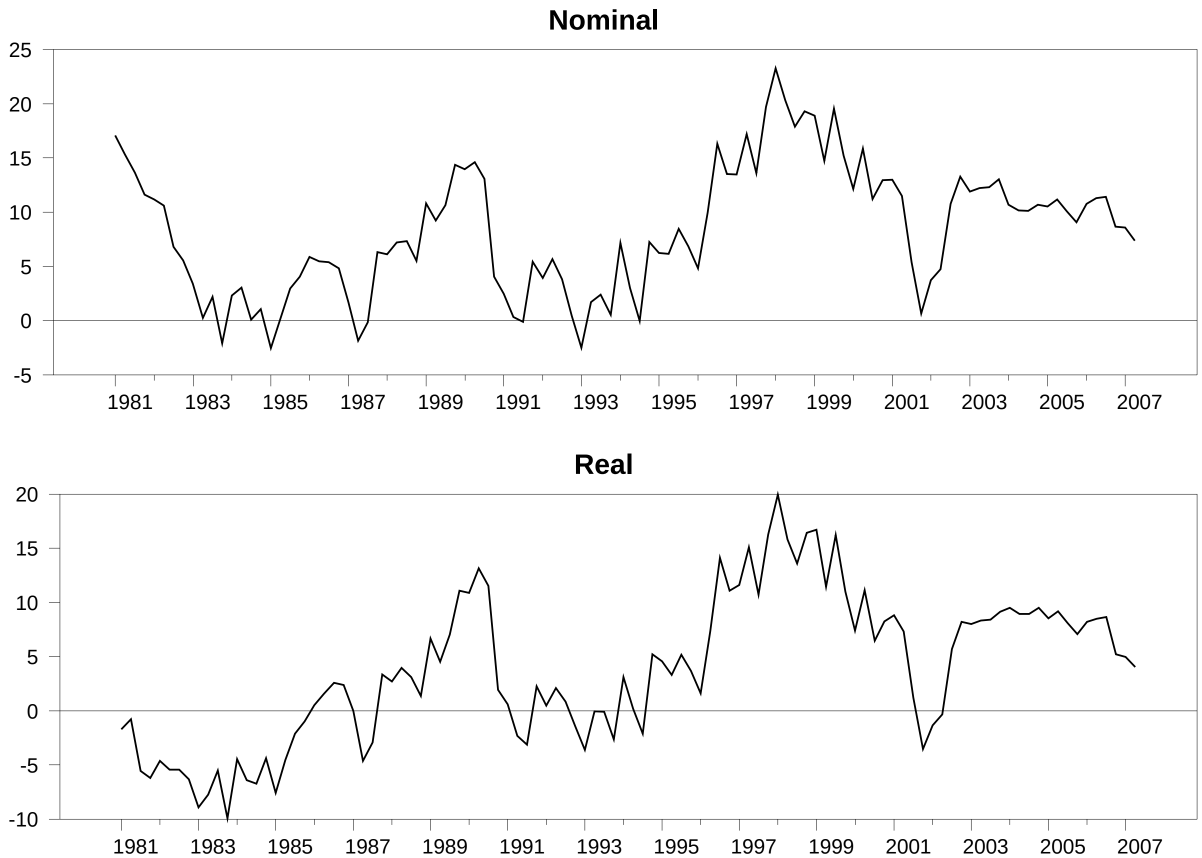

Figure 2: Irish House Price Partial and AutoCorrelation Functions

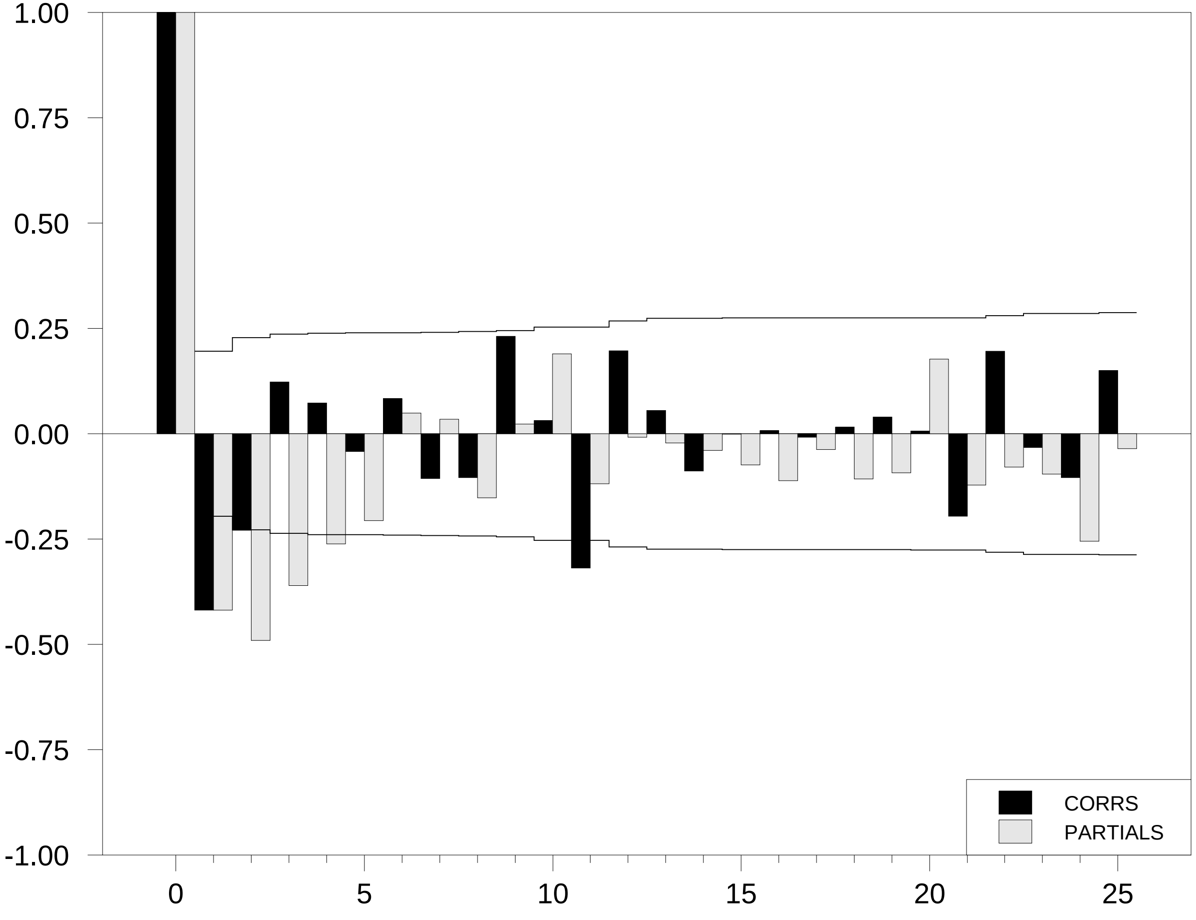

Figure 3: MA Forecasts of Irish House Price Inflation