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Assessing the sustainability of Irish residential property prices: 1980Q1-2016Q2

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Abstract

Developing indicators to assess the sustainability of house price movements is a key priority for macroprudential policy makers. Using historical data from the 1980s and cross-country comparisons, this *Letter* presents a number of indicators to support this requirement. The first approach uses a recursive unit root methodology to identify emerging explosive behaviour in prices based on the historical time series properties of the data and the asset-pricing literature. The second approach uses a simple reduced form model and the empirical housing literature to identify a fundamental house price series against which actual developments can be benchmarked. Such approaches can be used to complement traditional statistical indicators of price misalignments such as deviations of the price-to-rent ratio and the price-to-income ratio from their respective historical averages. Both approaches have some success in identifying "bubble" behaviour or overvaluation in the Irish market prior to the Irish crisis. The recovery in Irish house prices since 2013 has meant that the statistical indicators are currently above long-term averages. As at 2016Q2 prices are assessed to remain just below fundamental values using a suite of valuation models and are not suggestive of emerging bubble-like behaviour. Close monitoring of this market is required given the uncertainty associated with house price movements.

1 Introduction

Following a peak-to-trough fall of over 50 per cent between 2007 and 2012, Irish house prices have increased, recording positive annual growth rates since 2013. High growth rates during 2014, especially in the Dublin area raised concerns from a macroprudential risk perspective. Since 2015, the pace of growth has declined, coinciding with the introduction of the new macroprudential rules for new Irish mortgage lending ("regulations") introduced by the Central Bank of Ireland. Survey evidence suggests that market experts reduced their expectations for further house price growth around the time of the introduction of these regulations. National house prices, however, continue to increase and the latest data for September 2016 show annual growth of 7 per cent per annum. To complement existing analysis of the housing market, this *Economic Letter* presents a number of indicators that can be used to assess the sustainability of house price trends drawing on both ex-

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isting and new empirical approaches. A sustained period of house price growth raises concerns, especially if prices do not appear to be in-line with economic drivers (i.e., "fundamentals") as it increases the probability of a future correction. If house price growth is funded by excessive credit growth as per the Irish experience pre-2007, the impact of a downward adjustment can be particularly severe. Although growth in Irish house prices recently moderated and the credit channel is not fully operational, it is still important to ascertain how current prices compare to fundamentals. Irish house prices have been extremely volatile over the last two decades which presents modelling challenges. Therefore, this *Letter* uses a range of empirical approaches to determine valuation of Irish house prices using a long-run quarterly database from 1980 and international experience.

Established statistical indicators of misalignment (i.e., difference between actual prices and levels determined by fundamental values) use deviations of the price-to-income ratio and the price-to-rent ratio from their respective long-run averages. To complement these metrics, two empirical approaches from the asset pricing/housing literature are presented. The first approach, which draws on Phillips et al. (2011) and Phillips et al. (2015), uses univariate analysis of key individual series to test if there is emerging evidence of bubble-like behaviour. Although Phillips et al. (2015) apply the approach to the S&P500 there is a growing literature using the framework to detect bubbles in residential property prices. Greenaway-McGrevy and Phillips (2015) for instance, looking at the New Zealand market, adopt the approach to detect and date "irrational" deviations in house prices from rents and incomes. Chen and Funke (2013) apply the framework to the Chinese market while Yiu et al. (2013) examine the Hong-Kong market. Both Engsted et al. (2015) and Pavlidis et al. (2015) use the approach in cross-country studies of exuberance in housing markets.

The second approach uses an inverted demand framework to estimate a fundamental price series in the Irish market. Actual house prices are then, benchmarked relative to this series. This second approach is standard in the empirical housing literature and has been used in a variety of studies on both the Irish and international markets. Some examples are McQuinn (2004), McQuinn and O'Reilly (2006), Kennedy and McQuinn (2012) and McQuinn (2014). Some international studies are Capozza et al. (2002), Muellbaeur and Murphy (2008), Davis et al. (2011), Duca et al. (2011), Duca et al. (2016) and Corradin and Fontana (2013). For robustness a cross-country model of real house prices using panel cointegration techniques is also presented. The reduced form single equation models presented in this *Letter* focus on valuation and the identification of both long and short-run determinants of house prices. A full structural model is required to assess the dynamic interlinkages of house prices, mortgage credit and other macroeconomic aggregates. Duffy et al. (2016), for example present a structural model of credit and property markets in Ireland that can be used to assess macroprudential policy measures.

The *Letter* is constructed as follows. Section 2 introduces the data and presents an overview of Irish house price developments between 1980Q1 and 2016Q2. Section 3 outlines the two new empirical approaches to assess house price developments from a macroprudential risk perspective. Section 4 concludes.

2 Data

2.1 Data overview

The primary source for house price data is the CSO residential property price index. This series is only available post 2004, however, and is therefore combined with data from the Permanent TSB/ESRI House Price Index (1997 to 2004) and data from the Department of Housing, Planning, Community and Local Government (1980 to 1996) which are available for earlier periods. To obtain a real series, nominal values are deflated by the CSO's consumer price index.

Figure 1 shows the long-run house price index for the sample period, 1980-2016Q2. It is evident that the past two decades have been an extremely turbulent time for the Irish residential property market. The boom/bust period between 1995 and 2013 dominates earlier price movements. While initially, it could be argued that the growth in house prices during the mid-1990s reflected favourable economic and demographic factors, as well as a lowering of interest rates brought about by entry to EMU, the latter years of the price boom were fuelled by excessive credit growth, funded by the domestic bank loans and international capital flows. While many countries experienced house price booms during this period the increase in Irish prices was the largest across OECD members. Similarly, the Irish house price crash which followed was one of the most protracted and sizeable internationally with prices falling approximately 55 per cent between 2007 and 2013.

Against this background, the strength of the rebound in prices since 2013Q2 - annual growth in real terms of over 16 per cent occurred in 2014, a level similar to that witnessed during the housing boom - was a cause of some concern. While the mortgage market regulations do not directly target house prices, their introduction coincided with a more moderate rise in the value of residential property throughout 2015 and into 2016. The most recent data suggest that real house prices are growing at almost 7 per cent annually and the level of house prices is now about 35 per cent below peak levels.

While not without their limitations, statistical filters which decompose a time series into cyclical and trend components, can be used to benchmark current price levels relative to long-run trend levels.[2] Figure 2 shows Irish house prices relative to the trend determined by a Hodrick-Prescott (HP) filter. One of the key issues with the HP filter is the choice of smoothing parameter.[3] The importance of the choice of smoothing parameter is shown by the fact that a value of 100,000 (as is used by Goodhart and Hofmann (2008) and European Commission (2012)) implies prices are currently almost 10 per cent above trend, whereas, a value of 400,000, which has now become common in the context of the countercyclical buffer, implies prices remain below trend.

Other variables utilised in this paper include residential rental values, household disposable income, mortgage interest rates as well as data relating to population and housing stock. Figure 3 shows the evolution of these variables over time relative to house prices and a comprehensive overview of sources and adjustments is provided in the Data Annex.

2.2 Statistical indicators

A common starting point for assessing whether house price developments can be justified by economic fundamentals is the price-to-rent and/or price-to-income[4] ratio. One of the caveats associated with these simple indicators is that they do not take other relevant factors such as interest rates[5] or structural factors into account. This limitation notwithstanding, such indicators are useful as part of a broader suite of early warning indicators for assessing real estate risks.

Figure 4 shows both series over the sample period relative to their respective long-run averages. A similar overall pattern is seen in both series, with the index rising above the long-run average during 1999 and continuing to increase until reaching a peak in late-2006/2007. Following the property crash both series fall back toward their long-run average and indeed below it in the case of the price-to-income index. Reflecting the strong rebound in prices both series began to increase once again before levelling off more recently in line with the moderation in house price growth. Indeed particularly strong rental growth is putting downward pressure on the price-to-rent index at present. As of 2016Q2 the price-to-income index was almost 12 per cent above its long-run average. The corresponding figure for the price-to-rent index was almost 6 per cent.

As mentioned, Ireland was not alone in experiencing a residential real estate boom during the 2000s. Countries such as Spain, the Netherlands, the UK, Sweden and Denmark also witnessed robust house price growth in the early years of the 21st century. The OECD produces house price-to-disposable income per capita and house price-to-rent indices for these countries.[6] According to these data (Figure 5), Irish house prices were amongst the most misaligned prior to the housing crash, with Spain and Denmark also showing sub-

[2]See for example the IMF Financial Sector Assessment Program for Ireland (Technical Note - Nonbank sector stability analyses page 31) where statistical filters were among the methodologies employed to assess house price valuations.

[3]The HP filter decomposes a time series into a cyclical and trend component by minimising the deviation between the time series and the trend subject to a penalty for variations in the growth rate of the trend. The smoothing parameter (or lambda) determines how sensitive the trend is to short-term fluctuations in the time series. The higher the lambda value the smoother the trend will be. A lower lambda results in the trend more closely following the actual data.

[4]In this *Letter* disposable income per household is used as the measure of income.

[5]Interest rates play a role in determining the discounted future income flows for investors and in determining affordabiliy for households. In this context, the current prevailing low interest rate environment is a relevant consideration.

[6]The sample period runs to 2015Q4.

stantial deviations from average. Both Spain and Ireland experienced notable housing crashes, which saw their indices revert towards, and remain close to, long-run averages. This has not been the case in Sweden and the UK where the move away from their sample averages has been quite significant of late. We can also benchmark the Irish experience relative to European peers. This is particularly useful given the dramatic boom in the Irish case. As at 2016Q1, the Irish price-to-rent and the price-to-income indices are above the historical average for the euro area.

Overall, these simple statistical indicators would suggest that the collapse in Irish house prices initially brought house prices in line with and indeed below long-run averages or trends following the overheating of the boom. With the reacceleration in house price growth, particularly during 2014, the house price-to-rent and house price-to-household income indices are currently above historical averages.

3 Empirical approach

In this section we present two approaches to assessing house prices developments from a macro-prudential risk perspective. First we apply the recursive unit root approach of Phillips et al. (2015) to investigate whether or not prices display bubble type behaviour. Second, we model Irish real house prices using reduced form econometric techniques and test if actual prices are in line with fundamentally determined values.

3.1 A recursive unit root approach

This approach draws on the asset-pricing literature, and in particular, the theory of rational bubbles which contends that asset prices may contain both a fundamental and a bubble component under certain assumptions. This bubble component manifests itself as an explosive component in asset prices. Specifically, recursive estimation of a right-sided unit root test is used to identify (mildly) explosive behaviour and to date "bubble" episodes in Irish residential real estate prices over our sample.

The intuition behind the approach relies on the present value theory of asset pricing where the price of an asset reflects the discounted present value of its future income stream.

That is:

$$P_t = \frac{1}{1+R} E_t(P_{t+1} + D_{t+1}) \tag{1}$$

where P_t is the asset price, D_t the income received from ownership of the asset and R is the discount rate. Taking a log-linear approximation, as in Campbell and Shiller (1989), and through recursive substitution this yields the following price equation:

$$p_t = p_t^f + b_t \tag{2}$$

where the price (p_t) is made up of a fundamental component (p_t^f) which is based on future income and a bubble component (b_t). In the absence of a bubble prices are dominated by market fundamentals. However, in the presence of a bubble the asset price will be explosive and will not be stationary even in difference form. The GSADF test of Phillips et al. (2015) identifies non-stationarity by rejecting the null hypothesis of a unit root in favour of the alternative of mildly explosive behaviour. Evidence of non-stationarity in turn is interpreted as being suggestive of "bubble" behaviour in prices.

Consider the following autoregressive specification:

$$y_t = \alpha + \rho y_{t-1} + \epsilon_t \tag{3}$$

The GSADF test runs equation 3 recursively over subsamples of varying size.[7] The GSADF test statistic, which is the global supremum augmented Dickey-Fuller statistic, is used to detect the presence (or otherwise) of a bubble within the full sample. The time-series of backwards supremum augmented Dickey-Fuller (BSADF) test statistics is then used to date the episodes of explosive behaviour.

Initially, we apply the framework to the (log) real house price series itself. The results presented in Table 1 indicate that real house prices in Ireland did exhibit explosive behaviour over the sample period. Figure 6 shows the recursive BSADF test statistic against the simulated critical values[8].

[7] The GSADF test is an modification of the earlier SADF test of Phillips et al. (2011). The SADF, or sup ADF, test relied on recursions on a forward expanding window with a fixed starting point. The SADF test suffers from reduced power in circumstances where more than one bubble episode may be present, however. The GSADF test uses a more extensive recursion methodology where both the start and end point of the sample vary and is robust to multiple bubble episodes in the data.

[8] Critival values are simulated by EVIEWS rtadf add-in using 2000 repetitions.

Where the test statistic crosses above the critical value for the first time is deemed the beginning of the period of explosive behaviour - in this case late 1996. The bubble period extends right up until late 2007 when the test statistics falls below the critical value again. It is noticeable that the test statistic did fall significantly around 2002 although it generally remained above the critical value until 2007.

As mentioned above, house price developments are often assessed against developments in rents and/or income. Therefore, we also use the approach to test for explosive behaviour in the (log) price-to-rent ratio. Once again the null hypothesis of stationarity is rejected in favour of the alternative of mildly explosive behaviour (See Table 1) . Looking at the dating of the bubble episodes (figure 7), a similar pattern as to that in house price series itself is evident.[9]

In terms of assessing recent house price developments, there was some evidence of potential exuberant behaviour emerging during late 2011. This was short lived however and since then the results of this approach have not suggested a re-emergence of bubble type behaviour. A number of papers, for example Gallagher et al. (2015) and Lourenco and Rodrigues (2015), have applied a recursive unit root approach to Irish house prices. In most cases, however, they only assess the behaviour of the price series itself. In general results are similar to those found here.

3.2 A reduced form approach

Specifying house price models using a demand/supply framework and the application of reduced form econometrics is also popular in the empirical literature. This approach identifies potential explanatory variables based on economic theory that influence house prices over the long run in a particular market. Factors that influence both demand (e.g., income, interest rates, demographics) and supply for housing (e.g., existing housing stock, new development or construction costs) are typically included in the regression although the exact specification can vary across empirical studies. Standard house price theory states that in the short-run housing supply is inelastic due to construction lags, so house prices are determined by demand-side influences and other market-specific factors. In the long-run or in equilibrium, the housing stock is considered proportional to the demand for housing services (Poterba (1984), Meen (2002)). By inverting the demand equation, we can model house prices in terms of both demand and supply-side factors. The fitted values from this regression yields a fundamental price series. The difference between actual prices and the fundamental price series (i.e., residuals) shows the misalignment in the market. If prices are persistently out-of-line with fundamentals, a correction may be likely in the future.

Our first model ("Model 1") is specified as follows;

$$rhp_t = \beta_0 + \beta_1 y_t - \beta_2 hs_t - \beta_3 r_t + u_t \qquad (4)$$

where rhp_t is log real house prices, y_t is log real disposable income, hs_t is log of housing stock per person and r_t is average real mortgage rate[10]. It is assumed that income should have a positive influence on house prices in the long run while interest rates and the housing stock per person should be negatively associated with house price movements. The results from this regression are contained in the column labelled "Model 1" in Table 2.

The estimated relationships are in line with *a priori* expectations. With the exception of the mortgage rate, all of the other explanatory variables are in logs. Therefore, the coefficient point estimates show the various elasticities with respect to house prices. All other things being equal, a one per cent increase in disposable income is associated with a 1.8 per cent increase in house prices. This is a relatively high income elasticity but is broadly in-line with other literature, especially for the UK market [11]. The elasticity with respect to housing stock is also in line with other studies and shows that the long-run relationship is elastic (-2.6). An increase in the ratio of the housing stock per capita is associated with a decrease in house

[9] The results for the price-to-income ratio also point to explosive behaviour over the sample period but the date stamping shows the bubble episodes to be much less extensive than for the house price and price-to-rent series.

[10] Economic theory would include the user cost of capital (UCC) for housing services in this specification but as this variable is not observable many studies use real interest rates to proxy this variable. Including the user cost of capital based on Browne et al. (2013) in the Irish specification yields a very small point estimate for the UCC coefficient although correctly signed (i.e., negative) and statistically significant. Therefore, we include the real mortgage rate in the final specification.

[11] Meen (2002) finds the price elasticity with respect to income (real per household income) to be around 2.5 for the UK market (1969-1996) and the price elasticity with respect to the housing stock to be around -1.9.

prices in the long-run, all other things being equal. As expected, higher mortgage rates are associated with lower prices in the long-run.

Much of the criticism of the inverted demand approach is that the long-run elasticities with respect to house prices may not be stable over time (Gallin (2006)). We therefore run a number of robustness checks on our long-run specification. First, to check the stability of our point estimates for the individual explanatory variables, we recursively estimate Model 1 (Equation 4).[12] There are some concerns about the estimated price elasticities with respect to housing stock as they appear to change sign over the sample. Therefore, we also estimate a number of alternative reduced form specifications for robustness. The second Model ("Model 2") focuses purely on demand-side determinants using the following equation,

$$rhp_t = \alpha_0 + \alpha_1 emp_t + \beta_2 hh_t - \beta_3 r_t + \epsilon_t \quad (5)$$

where emp_t is seasonally adjusted numbers employed in logs, hh_t is the share of the population at household formation age (i.e., 25-44 years), also in logs and r_t is our real mortgage rate. Both employment and the demographic variable should have a positive influence on house prices in the long run while interest rates are expected to be negatively related. The third model ("Model 3") includes an annual measure of household mortgage affordability ($afford_t$) from McQuinn and O'Reilly (2006) in logs[13] and our log housing stock per person variable, hs_t.

$$rhp_t = \gamma_0 + \gamma_1 afford_t - \gamma_2 hs_t + \eta_t \quad (6)$$

The results from both models are contained in Table 2 under the columns labelled "Model 2" and "Model 3" respectively. The variables are all statistically significant and the signs on the coefficients are in line with theory. Figure 8 compares real house prices, the estimated fundamental levels across the three approaches and the corresponding estimated percentage misalignment up to 2016Q2. Estimated percentage misalignments from all three models follow a similar trend. Prices were persistently above fundamental values, from late-2000s up to 2010 while more recently, prices remain undervalued. Focusing in on the period where the mortgage market regulations were introduced and in effect over our sample (i.e., 2014Q4 through 2016Q2) all specifications show house prices to be below fundamentally determined values (i.e., undervalued) during this period. Prior to the announcement of the regulations in 2014Q4, there appears to have been a general decline in the levels of undervaluation in the market as actual prices began to catch-up with fundamental values. The recovery in the domestic macroeconomy, low interest rate environment and weak housing supply response led to an increase in both actual and fundamental prices. As noted, since 2015, house prices continue to grow but at a slower pace than recorded in 2014. Therefore as at 2016Q2, the gap between actual and fundamental prices remains.

3.2.1 Cross-country model

As a further cross-check on our long-run models, we also estimate a long-run model using the same inverted demand approach on European data over the period 1999Q1 through 2016Q1 using panel cointegration techniques. Specifically, we estimate the following equation for log of real house prices,

$$rhp_{i,t} = \tau_{i,0i} + \tau_{i,1} lnincome_t - \gamma_{i,2} r_t + \eta_{i,t} \quad (7)$$

where $lnincome$ is the log of household disposable income per capita[14] and r_t is the average mortgage rate[15] in each country i. Based on data availability

[12] Results are available upon request.

[13] McQuinn and O'Reilly (2006) present a simple theoretical model relating housing demand to the average amount that can be borrowed from credit institutions to purchase a house. The average amount that can be borrowed is based on a standard annuity formula and provides a measure that captures mortgage affordability in the market. Specifically, average mortgage repayments are calculated using data on personal disposable income and prevailing mortgage rates and assumptions regarding the proportion of income spent on these repayments and the duration of the mortgage.

[14] Quarterly household disposable income is sourced from the ECBs Statistical Data Warehouse while annual population figures are taken from the OECD. Population projections from 2014 through 2016 are taken from Eurostat. These annual population figures are then interpolated to obtain a quarterly series.

[15] The average mortgage rate series was constructed using ECB representative rate data, where available. Data are monthly and compacted to quarterly. Where data were not available or there were gaps it in the series, we drew on ESRB work on structural features in European housing markets which identified certain markets as having predominantly fixed rate mortgages and other markets having predominantly variable rates mortgages. For the former we used long-dated bond yields while for the latter we used short-term money market rates in these countries as a proxy.

there are 13 countries in our sample, namely Austria, Belgium, Germany, Denmark, Spain, Finland, France, United Kingdom, Ireland, Italy, Netherlands, Portugal and Sweden. We have 69 panel observations per country with a total of 897 observations. To capture supply-side dynamics, we also initially included each country's share of national investment (i.e., gross fixed capital formation) that can be attributed to dwellings as a percentage of GDP. However, this variable yielded a positive sign which is inconsistent with theory and so was excluded from the model.

Using methods developed by Pedroni (2007), we estimate a panel cointegration model using Fully-Modified OLS which attempts to correct for any potential bias due to serial correlation in the residuals. Heterogeneous cointegrating vectors are assumed which means that the long run equation is estimated country by country. This is considered a plausible assumption given the country-specific structural features that influence European housing market cycles. To aggregate up the results, we assume a simple average of each coefficient estimate. The results are contained in Table 3. The signs of the coefficient point group estimates are consistent with theory and statistically significant. The price elasticity with respect to income is 1.6 while the semi-elasticity with respect to interest rate is -0.01. These are broadly similar to our elasticity estimates in Table 2 for Models 1 and 2.

3.2.2 Short-run Model

In the short run, prices changes are modelled using an error-correction framework whereby lagged values of the residuals (i.e., an error correction term) from Model 1 are included in the specification to capture the tendency for prices to mean revert over time along with other short-run determinants. In addition to the error correction term (u_{t-1}), lagged real price growth and lagged real mortgage credit growth are also included in the following regression,

$$\triangle rhp_t = u_{t-1} + \sum_{i=1}^{p} \alpha_i \triangle rhp_{t-i} + \sum_{i=0}^{q} \alpha_i \triangle i_{t-i} + \sum_{i=0}^{q} \alpha_i \triangle cred_{t-i} + \tau_t \quad (8)$$

Using a general-to-specific approach to obtain a parsimonious specification, we obtain the results in Table 4. The short-run results show that prices will adjust to any deviation from long-run values at a rate of 7 per cent per quarter. House price changes also exhibit a high degree of autocorrelation and persistence over the sample while lagged credit growth exerts a positive influence. Figure 9 shows our actual and fitted values for the short-run model along with the residuals. The model fits the data well and the misspecification tests show no sign of ARCH effects or autocorrelation [16].

4 Conclusions

This *Letter* has presented a number of empirical techniques that can be used to complement existing indicators to assess the sustainability of house price developments. Such indicators can help to detect emerging imbalances in house price movements and can therefore contribute to existing early warning indicators for macroprudential policy makers. The first approach uses a recursive unit root approach to identify explosive behaviour in prices based on the historical time series properties of the data. The second approach uses economic theory to try to identify a fundamental house price against which to compare actual developments. Both approaches have some success in identifying "bubble" behaviour in the Irish market prior to 2007.

While simple indicators relating Irish house prices to household incomes and rents are currently above historical averages and point to the need for careful monitoring, the empirical techniques employed in this *Letter* do not provide (conclusive) evidence of emerging bubble-like/ unsustainable price behaviour up to 2016Q2. Although the fundamental factors driving house prices are currently favourable, this could change due to a negative economic shock. It is also the case that factors not taken account of by the models (e.g. fiscal factors, a change in market sentiment or a change in credit availability) could exert an influence on prices.

[16] Given the potential for structural change over the sample further work will investigate the non-linear approach used by Corradin and Fontana (2013) and based on Hall et al. (1997) to test regime switches over the sample. Initial results show that while there is some evidence of discrete regime shifts in the short-run model over the sample, the conditional mean does not appear to change or conform to Hall et al. (1997). The error correction term remains negative and significant in both regimes.

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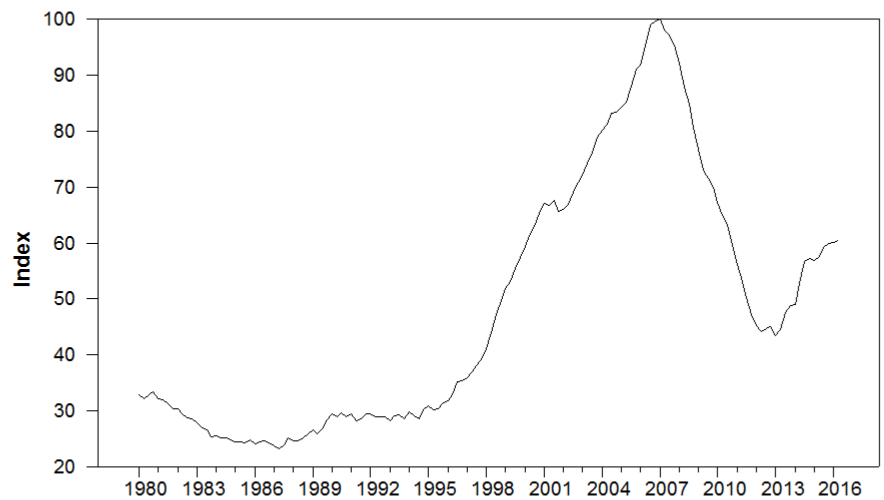
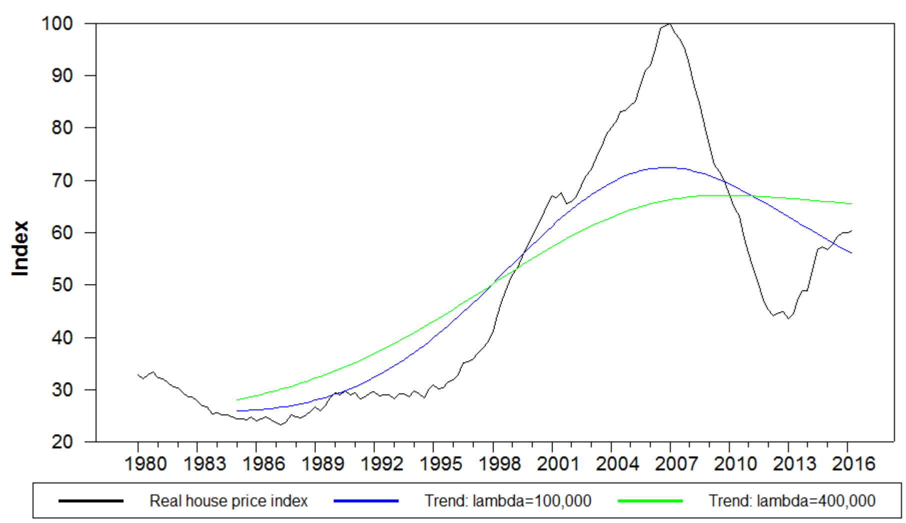
Figures

Figure 1: Irish real house prices: 1980Q1-2016Q2



Notes: Index = 100 in 2007Q1.

Figure 2: Irish real house prices relative to trend



Notes: Index = 100 in 2007Q1. Trend is calculated using a Hodrick-Prescott filter.

Figure 3: Irish real house prices and fundamental determinants:1981Q1-2016Q2

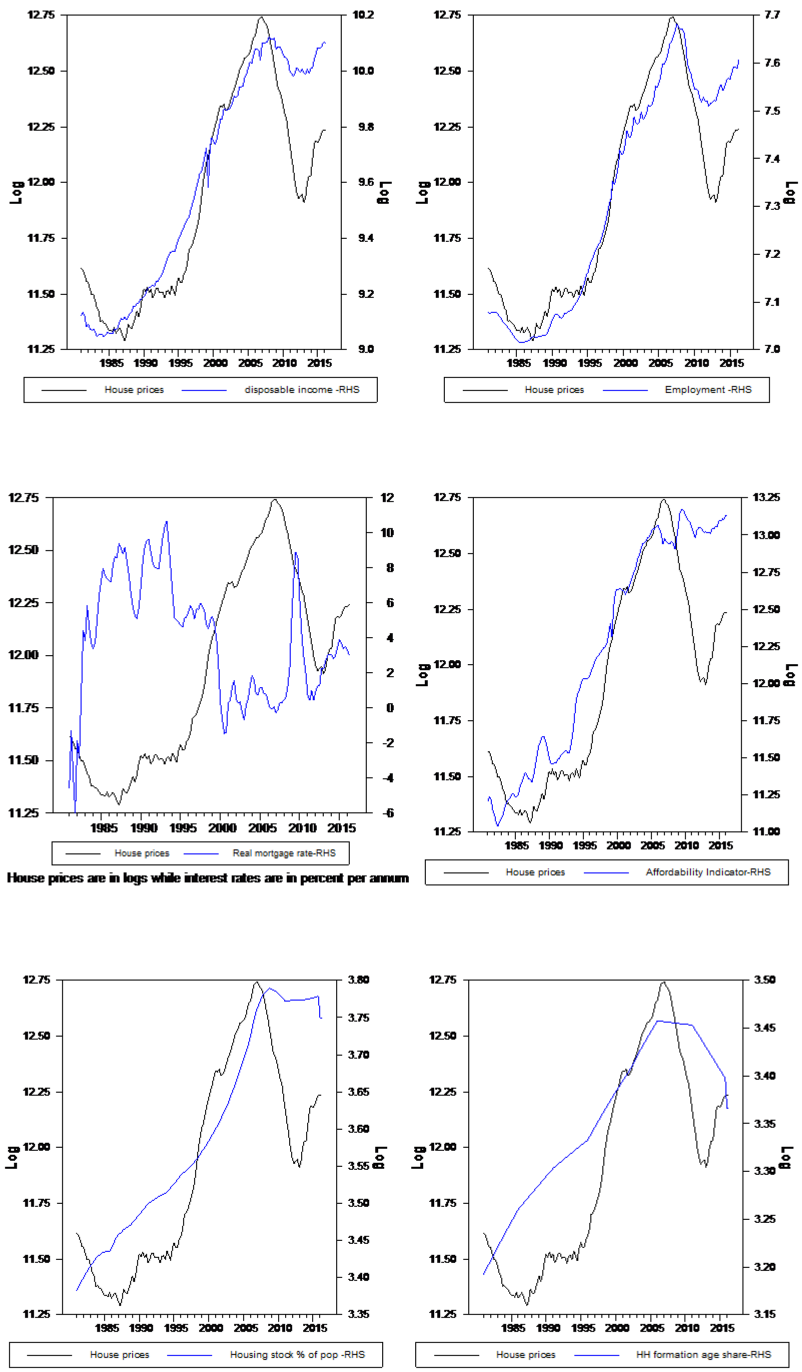


Figure 4: Irish house prices relative to rents and incomes

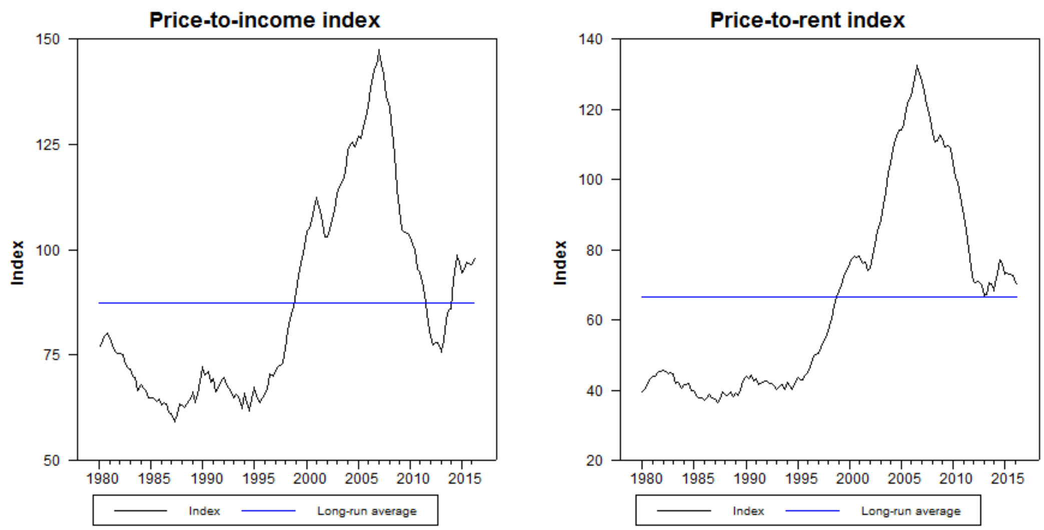


Figure 5: House prices relative to rents and incomes - selected countries

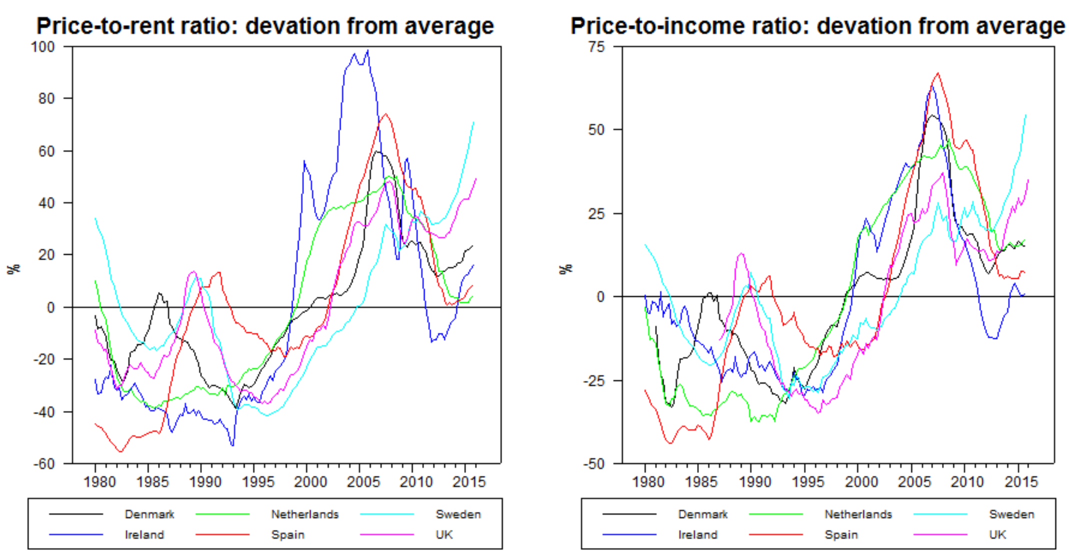


Figure 6: GSADF test: real national house prices

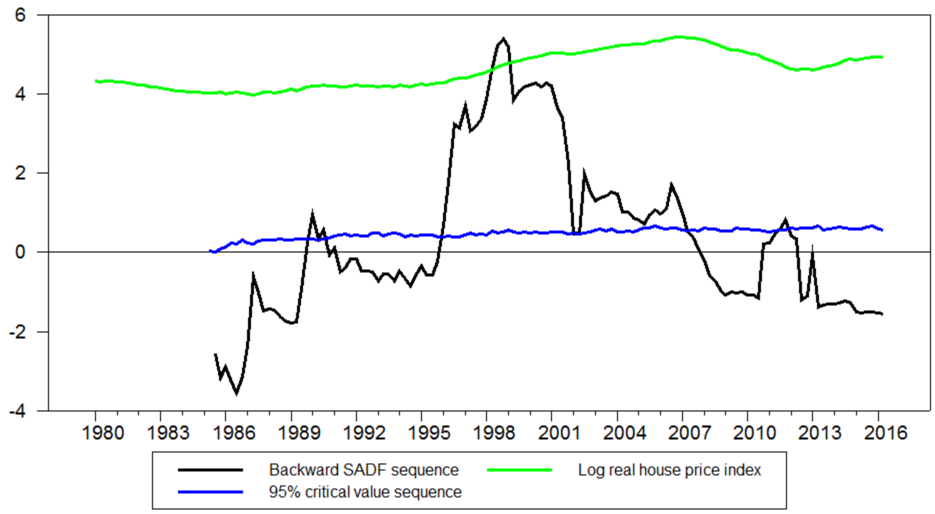


Figure 7: GSADF test: national house price-to-rent ratio

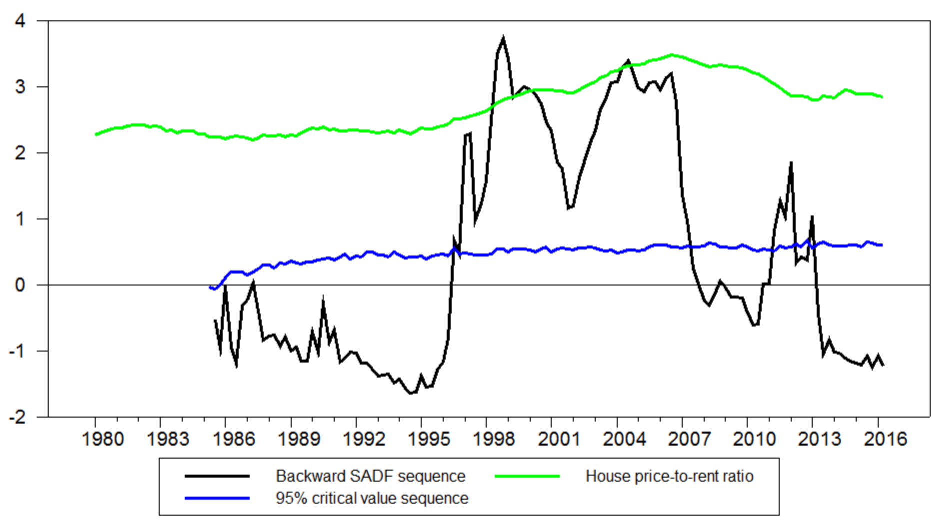


Figure 8: Long-run models of Irish real house prices: 1981Q1-2016Q2

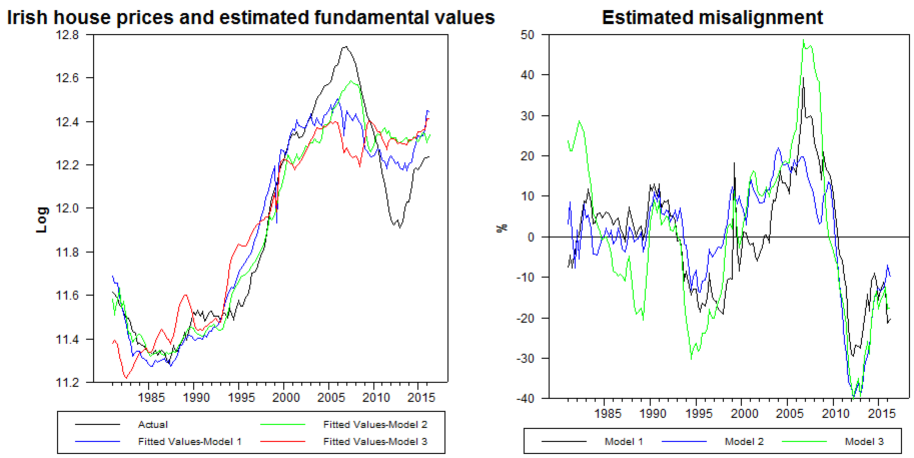
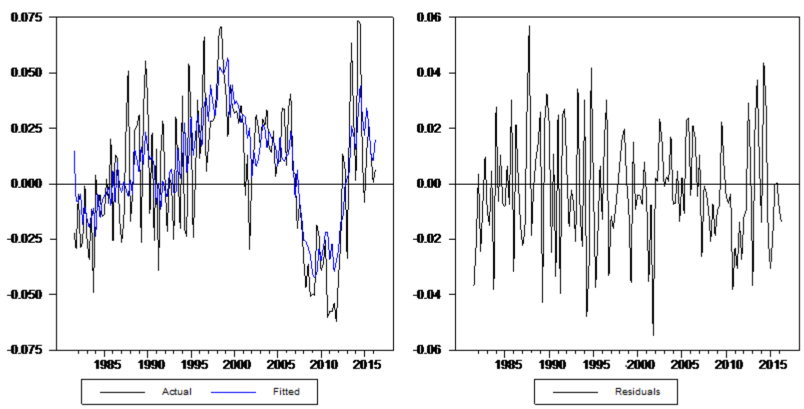


Figure 9: Short-run models of Irish real house prices: 1981Q1-2016Q2



Tables

Table 1: GSADF test

	GSADF statistic
Log real house prices	4.689*
Log price-to-rent ratio	4.741*

Notes: * denotes significance at the 1% level. GSADF test was undertaken using EVIEWS rtadf addin with number of lags determined by AIC, subject to a maximum of 4 lags. The default window length was used based on the formula *win* = [T(0.1 + 1.8/$\sqrt{T}$)].

Table 2: Long-run models of Irish real house prices: 1981Q1 to 2016Q2

Dependent variable: rhp_t			
	Model 1	**Model 2**	**Model 3**
$constant$	3.903	-1.464	7.343
	(11.85)	(-2.59)	(10.34)
$income_t$	1.821		
	(14.99)		
$employment_t$		1.356	
		(6.93)	
$affordability_t$			0.770
			(9.57)
i_t	-0.011	-0.019	
	(-2.78)	(-3.91)	
$Stock_t$	-2.598		-1.340
	(-7.51)		(-3.02)
hh_t		1.053	
		(2.06)	

Note: Absolute t-statistics in brackets. Dependent variable is log real house prices. $income_t$ is seasonally adjusted log real personal disposable income, $employment_t$ is seasonally adjusted log employment, $affordability_t$ is log real affordability indicator based on McQuinn and O'Reilly (2006), i_t is real average mortgage rate, $Stock_t$ is log of total housing stock per person and hh_t is the share of the population at household formation age (i.e., 25-44 years).

Table 3: Panel estimates of long-run real house prices: 1991Q1 to 2016Q1

Dependent variable: rhp_t

Country	Variable	Coefficient	t-statistic
Austria	Income	0.826	2.69
	Interest rate	0.007	0.45
Belgium	Income	0.741	3.64
	Interest rate	-0.026	-2.52
Germany	Income	4.002	7.25
	Interest rate	0.024	2.21
Denmark	Income	1.886	3.14
	Interest rate	0.021	0.79
Spain	Income	2.769	6.41
	Interest rate	-0.046	-2.22
Finland	Income	0.828	4.63
	Interest rate	-0.006	-0.57
France	Income	1.649	4.68
	Interest rate	-0.067	-3.01
United Kingdom	Income	2.648	8.39
	Interest rate	0.016	1.68
Ireland	Income	2.770	15.2
	Interest rate	0.002	0.14
Italy	Income	1.891	6.42
	Interest rate	-0.030	-1.6
Netherlands	Income	0.343	1.77
	Interest rate	-0.003	-0.15
Portugal	Income	0.398	3.82
	Interest rate	-0.006	-0.87
Sweden	Income	0.031	0.22
	Interest rate	-0.015	-1.13
Group	Income	1.599	18.93
	Interest rate	-0.010	-1.89

Note: Panel FM-OLS estimates used to estimate the heterogenous cointegrating vectors for log real house prices. The Group estimates are a simple average. Income refers to log real household disposable income per capita and interest rate is the representative real mortgage rate in each country.

Table 4: Short-run model of Irish real house prices: 1981Q1 to 2016Q2

Dependent variable: $\triangle rhp_t$	
ecm_{t-1}	-0.065
	(-4.78)
$\triangle rhp_{t-1}$	0.282
	(3.79)
$\triangle rhp_{t-3}$	0.246
	(3.18)
$\triangle rhp_{t-4}$	0.162
	(2.22)
$\triangle rcred_{t-3}$	0.201
	(3.29)
$\overline{R}^2$	0.53

Note: Absolute t-statistics in brackets. Dependent variable is first difference log real house prices and $\triangle rcred$ is first difference log real mortgage credit. Heteroscedasticty-robust standard errors used.

Data annex

The variables utlisied in the paper are as follows:

- The CSOs residential property price index (2005 to present) is combined with with earlier data from the Permanent TSB/ESRI House Price Index (1997 to 2004) and the Department of Housing, Planning, Community and Local Government (1980 to 1996). The hedonic PTSB/ESRI house price series provides a house value which is rolled forward using changes in the CSOs hedonic residential property price index (national, all-properties) and "backcast" for the time before its inception, using changes in the Department of Housing, Planning, Community and Local Governments quarterly average new property price series.
- A long-run rental value series is calculated by applying the CSOs private residential rental index to the estimated monthly asking rent in 2016Q1 from Daft.ie.
- Household disposable income is available on a quarterly basis from the CSOs Institutional Sector Accounts from 1999Q1 onwards. The series is extended back to 1980 on the basis of an internal Central Bank personal disposable income series.
- Mortgage interest rate data come from the Central Bank of Ireland. Data between 1980 and 2002 are median interest rates on loans for house purchases. From 2003 interest rates on floating rate loans for house purchases for up to 1 year are used.
- Population and household formation cohort data are sourced from annual CSO population projections and census returns. Data are interpolated to obtain quarterly frequency.
- Annual housing stock data is sourced from the Department of Housing, Planning, Community and Local Government. Quarterly data are interpolated and adjusted pre-1991 to take account of vacant units.

Where relevant nominal series are deflated using the CSOs consumer price index (CPI).