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ARE HOUSE PRICES NEARING A PEAK? A PROBIT ANALYSIS FOR 17 OECD COUNTRIES

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ABSTRACT/RÉSUMÉ

Are House Prices Nearing a Peak? A Probit Analysis for 17 OECD Countries

House prices have been moving up strongly in real terms since the mid-1990s in the majority of OECD countries, with the ongoing upswing the longest of its kind in the OECD area since the 1970s. If interest rates were to rise significantly, real house prices may be at risk of nearing a peak. The historical record suggests that the subsequent drops in prices in real terms might be large and that the process could be protracted. To quantify the probability that a peak is nearing in the current situation a probit model was estimated for the period 1970-2005 on a restricted set of what are generally agreed to be the main explanatory variables. Aside from interest rates, these include measures of overheating, such as the gap between real house prices and their long-run trend and the rate of change in real house prices in the recent past. The main finding is that an increase in interest rates by about 1 to 2 percentage points would result in probabilities of a peak nearing of 50% or more in the United States, France, Denmark, Ireland, New Zealand, Spain and Sweden.

JEL codes: E32, E52, F42.
Keywords: house prices, financial markets, business cycles.

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La hausse des prix des logements touche-t-elle à son terme ? Une analyse probit pour 17 pays de l'OCDE

Les prix des logements ont fortement augmenté en termes réels depuis le milieu des années 90 dans la majorité des pays de l'OCDE, et leur augmentation actuelle est la plus longue que la zone OCDE ait connue depuis les années 70. Si les taux d'intérêt venaient à augmenter sensiblement, la progression des prix réels des logements pourrait toucher à sa fin. Les évolutions passées donnent à penser que les baisses de prix qui s'ensuivraient pourraient être importantes en termes réels et que le processus d'ajustement pourrait durer un certain temps. Pour mesurer la probabilité que les prix cessent d'augmenter dans la situation actuelle, un modèle probit a été estimé sur la période 1970-2005 pour un ensemble restreint de ce que l'on considère en général comme les principales variables explicatives. En plus des taux d'intérêt, ces variables comprennent des indicateurs de surchauffe, comme l'écart entre les prix réels des logements et leur tendance de long terme, ainsi que le taux de variation des prix réels des logements au cours de la période récente. L'analyse démontre qu'une hausse de 1 ou 2 points des taux d'intérêt ferait passer à 50 % ou plus la probabilité d'un retournement du marché aux États-Unis, en France, au Danemark, en Irlande, en Nouvelle-Zélande, en Espagne et en Suède.

Classification JEL : E32, E52, F42.
Mots-clés: prix des logements, marchés financiers, cycles conjoncturels.

ARE HOUSE PRICES NEARING A PEAK? A PROBIT ANALYSIS FOR 17 OECD COUNTRIES

Paul van den Noord[1]

Introduction

1. House prices have been moving up strongly in real terms since the mid-1990s in the majority of OECD countries, with the ongoing upswing the longest of its kind in the OECD area since the 1970s. As reported in Girouard *et al.* (2006), several measures, such as the user cost of owner-occupied housing and affordability indicators, suggest that house prices are not that much out of line with the fundamentals in most markets. However, the extent to which real house prices look to be fairly valued depends critically on interest rates remaining at or close to their recent historical lows. Interest rates have already edged up since late 2005, and, if they were to rise significantly further, real house prices may be at risk of nearing a peak. The historical record suggests that the subsequent drops in prices in real terms might be large and that the process could be protracted. This would have negative implications for activity, which in turn could necessitate a monetary policy response.

2. Against this backdrop, this paper provides estimates of the probability that real house prices are nearing a peak, both at present and if interest rates were to rise in the near term. The approach is to estimate a probit model on a set of what are generally agreed to be relevant explanatory variables. Aside from interest rates, these include measures of overheating, such as the gap between house prices and their long-run trend, and the rate of change in real house prices in the recent past. Simulations are carried out in which interest rates are assumed to increase by 100 or 200 basis points. The results are reported for two cases: one in which real house prices are kept at their most recently observed levels (case 1) and one in which real prices are assumed to rise (or fall) for another year at the same pace as in 2005 in each country (case 2). The latter case serves to illustrate the increasing vulnerability of housing markets to interest rate shocks at current price trends. The main findings are twofold:

- *First*, housing markets in most countries look likely to be resilient against a 1 or 2 percentage-points hike in long-term interest rates from their levels observed in the fourth quarter of 2005 if it kicked in at current house price levels, except for Denmark and New Zealand where the probability of a downturn in house prices in real terms would be close to 50%.

- *Second*, this picture changes considerably if real prices are assumed to increase in each country for another year at their observed 2005 pace. In that situation, an increase in interest rates would raise the probabilities of a peak nearing to 50% or more in the United States, France, Ireland, Spain and Sweden.

3. The first section of the paper reviews the stylised developments in OECD housing markets. The second section lays out the assumptions underlying the analysis, including the procedure that has been applied to date past peaks in real house prices -- which is a necessary ingredient of the probit regression approach. The next two sections presents the results for, respectively, pooled regression and individual country regressions. The final section concludes.

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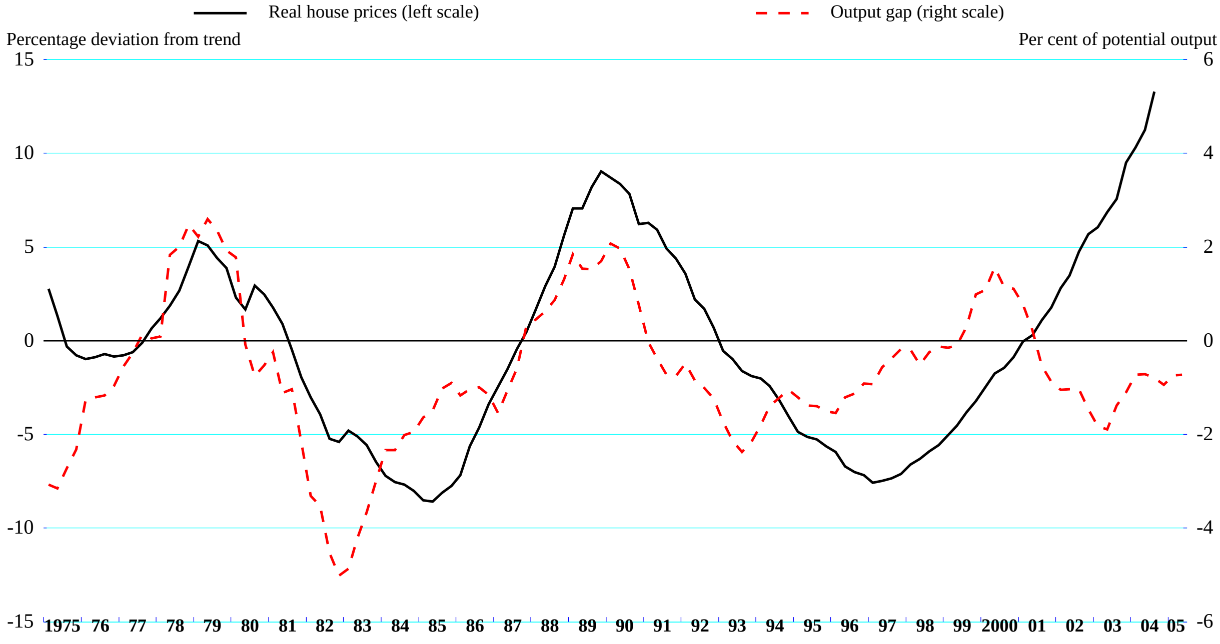
1. The author is senior economist in the Economics Department; e-mail: paul.vandennoord@oecd.org. He is indebted to several colleagues in the Department for helpful comments. The views in this paper are the author's and should not be attributed to the OECD or its member countries.

Stylised developments

4. Since the 1970s, house prices in real terms (the ratio of actual house prices to the consumer price index) in the OECD have been on a secular upward trend, rising by on average 3% *per annum* in the area as a whole (Table 1). This is generally attributed to rising demand for housing space linked to increasing *per capita* income, growing populations, supply factors such as land scarcity and restrictiveness of zoning laws, quality improvement that is not properly taken into account in the price index and comparatively low productivity growth in construction.[2] Wide fluctuations around this trend have also been apparent, with the duration of the cycle tending to become longer and its amplitude larger. The current boom is in line with these tendencies, but it is different in other respects. Specifically, the current upswing is more generalised across OECD countries than in the past and strikingly out of step with the business cycle (Figure 1). Until the mid-1990s the OECD average output gap and real house price index were highly correlated, but this correlation has broken down since (see Girouard *et al.,* 2006). This suggests that global factors have been at work to sustain the current housing boom. These factors include the easing of monetary policy stances in the wake of the 2000-01 downturn and the associated massive injection of liquidity, the exceptionally low levels of term premiums on longer-term bond yields and easier access to credit owing to the liberalisation of mortgage markets.

Figure 1. OECD Real house prices and the business cycle



Note: Real house prices have been detrended using a linear trend. The OECD aggregate has been computed using GDP weights in 2000 in purchasing power parities.
Source: OECD Economic Outlook 78 database and OECD calculations.

2. See for example Helbling (2005).

Table 1. Developments in real house prices

Average percentage annual rates of change

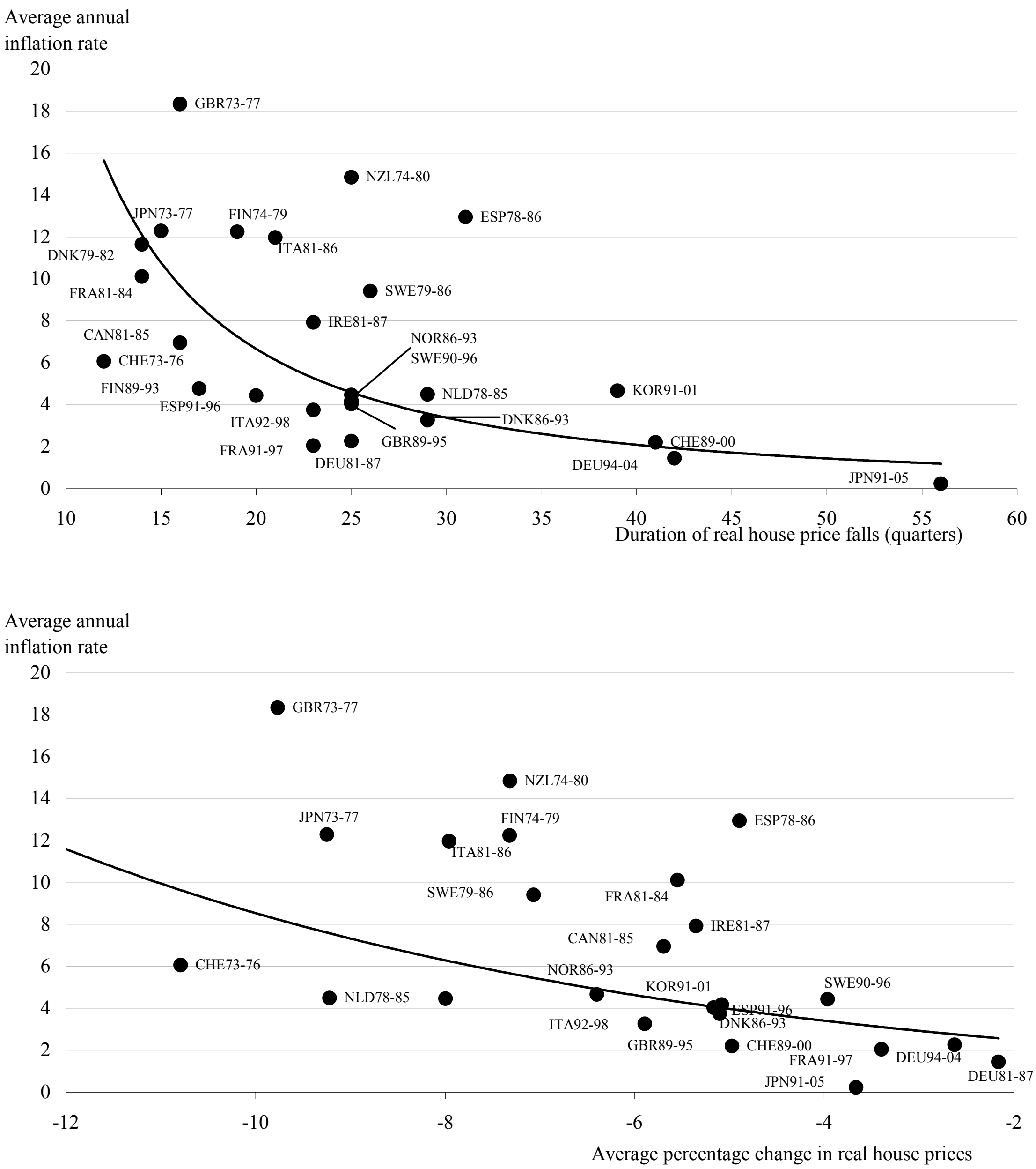
	1970-1975	1975-1980	1980-1985	1985-1990	1990-1995	1995-2000	2000-2005
United States	1.6	1.4	1.2	1.1	-1.1	2.3	6.4
Japan	3.0	2.1	1.2	0.5	-2.9	-2.6	-4.6
Germany	0.5	0.0	-0.4	-0.7	0.8	-1.6	-2.8
France	1.8	2.2	2.7	3.2	-2.7	2.1	9.4
Italy	6.4	6.4	6.6	7.1	-1.8	-0.9	6.6
United Kingdom	5.0	4.4	4.0	3.7	-4.4	8.1	9.9
Canada	6.6	6.8	6.8	6.9	-1.0	0.0	5.9
Australia	4.6	4.3	4.0	3.6	-0.2	3.5	7.7
Denmark	3.9	4.0	3.8	3.4	1.8	6.7	5.5
Finland	0.9	0.4	0.2	0.0	-10.2	7.8	3.8
Ireland	1.3	1.2	1.0	0.7	1.0	17.6	7.8
Netherlands	3.0	3.4	4.0	4.9	4.6	10.8	2.6
New Zealand	8.4	7.8	7.3	6.9	2.8	1.7	9.8
Norway	0.5	0.4	0.6	0.7	-0.6	9.3	4.5
Spain	3.8	2.5	2.4	2.5	-1.6	2.6	12.2
Sweden	1.2	1.7	2.0	2.5	-5.8	6.3	6.0
Switzerland	0.8	0.0	-0.6	-1.3	-6.0	-2.7	1.5
Average	3.1	2.9	2.8	2.7	-1.6	4.2	5.4
Average excluding Germany and Japan	3.3	3.1	3.1	3.1	-1.7	5.0	6.6

Source: updates of series reported in Girouard *et al.* (2006).

5. As noted, evidence from various measures -- such as those derived from econometric models, affordability indicators and asset-pricing approaches -- suggest that house prices are not that much out of line with the fundamentals in most markets (Girouard *et al.*, 2006). For example, the general increase in indebtedness, which is another striking feature of the current upswing, has been mostly offset by the decline in borrowing rates. As a result, households do not seem to devote a greater share of their income to debt service than in the not-too-distant past. A comparison of price-to-rent ratios with the inverse of the imputed user cost of housing over the past ten years also does not suggest that real house prices are greatly overvalued in most markets, and where they do, it can be explained by features that are particular to those markets, such as restrictions on the availability of land for residential housing development becoming more acute due to tough zoning rules, cumbersome building regulations and slow administrative procedures.[3]

3. See Evans and Hartwich (2005). These factors may be expected to affect both rents and prices and therefore should not affect the price-to-rent ratio in the long run. However, in the short run prices are more responsive than rents (which are often regulated), hence supply constraints tend to durably raise the price-to-rent ratio.

Figure 2. Inflation and the duration of real house price adjustment



Source: Girouard *et al.* (2006).

6. However, the extent to which real house prices look to be fairly valued depends critically on interest rates remaining at or close to their current historical lows. If interest rates were to rise significantly, house prices would come under downward pressure as the user cost would fall out of sync with the prevailing price-to-rent ratios or because affordability constraints kick in. Real house prices would have to adjust downwards, but with inflation lower than in previous episodes, a bigger share of the burden of the adjustment will need to be borne by nominal house price decreases. However, nominal house prices tend to exhibit downward stickiness: when overall conditions weaken, owners of existing homes tend to withdraw from the market rather than suffer a capital loss, while builders will develop fewer new properties. As a result, in a low inflation environment the adjustment of real prices will be drawn-out. This is illustrated by the negative cross-country correlation observed between the level of inflation and the duration of house-price-contraction phases, although there is also a tendency for real prices to fall less at low inflation (Figure 2). The upshot is that the effects of the adjustment may be less disruptive than in past episodes of contraction but may also depress economic activity for a longer period.

7. There are several main channels through which falls in real house prices affect activity:

- *Wealth effects on private consumption*. These occur either via saving responses to households' perceived wealth or via collateral effects on household borrowing (Catte *et al.,* 2004). In a number of countries (Australia, Canada, the Netherlands, the United Kingdom and the United States) this effect is significant, in part because these countries have been frontrunners in providing easy access to mortgage products that facilitate house equity withdrawals.

- *Effects on private residential investment*. Changes in the profitability of housing investment affect the construction sector as well as employment and demand in property-related sectors. A number of other factors may cushion the profitability effect. Specifically, supply constraints in the form of planning restrictions, the availability of land or the competitive conditions in the construction sector may act to smooth the production cycle by holding down housing investment in the upswing.

- *Effects on the banking sector*. Banks may be reluctant to make adequate provision for their loan losses when housing markets are buoyant, and supervisors may be reluctant to suggest it without solid evidence (Dobson and Hufbauer, 2001). Hence, when a large shock occurs, banks may find themselves with inadequate cushions to absorb the loss, which could affect credit availability. This could in turn adversely affect macroeconomic performance overall.

Basic assumptions underpinning the analysis

8. Housing markets have in common with many (other) asset markets a high degree of cyclicality, with downturns occurring suddenly if risk factors exceed critical thresholds. Probit modelling can be used to capture such "trigger effects" in aggregate series and was successfully applied to aggregate series for house prices in a recent study carried out at the Bank for International Settlements (BIS) by Borio and McGuire (2004).[4] They estimate a probit model on a pool of countries to examine a possible link between peaks in stock markets and housing markets (which is generally confirmed).

9. In the probit model developed here, the dependent variable is the probability P_{it} of a house price peak occurring in country *i*. It is assumed that this probability can be described by the *S*-shaped cumulative standard normal distribution. This distribution, denoted as $P_{it}=F(Z_{it} > Z^*_{it})$, calls the probability of a peak if a latent variable Z_{it} exceeds a threshold Z^*_{it}. The latent variable can take any value between $-\infty$ and ∞. It is

4 . An alternative binary response approach that has been successfully applied is the Markov-switching model; see Ceron and Suarez (2006).

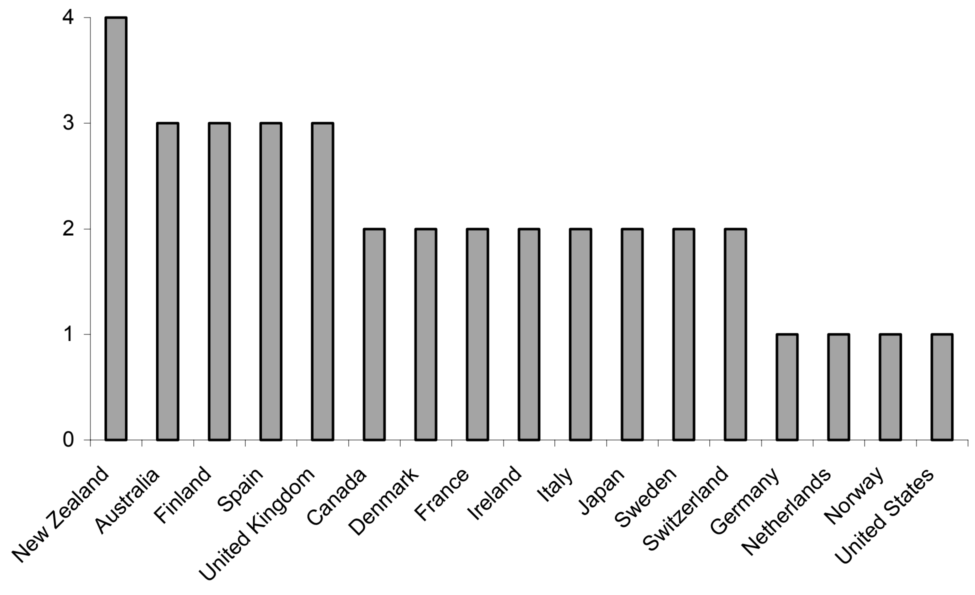
unobserved, but assumed to be a linear function of explanatory variables X_{it-j} and their respective weights. The size of each of those weights can be estimated via a standard procedure to maximise the goodness of fit of the function F on a set of dummy variables which for any country i in quarter t take a value 1 if a peak is called, and otherwise take a value 0. If the threshold Z^*_{it} is assumed to be a normally distributed random variable with zero mean, the probability that Z_{it} is less than (or equal) to Z^*_{it} is exactly described by the cumulative standard normal distribution $P_{it}=F(Z_{it}> Z^*_{it})$.

10. The dating of peaks in real house prices is a crucial ingredient of the analysis and therefore merits some discussion. All available dating techniques contain elements of arbitrariness. Here the same procedure is used as in Girouard *et al.* (2006), who apply the Bry and Boschan (1971) cycle-dating procedure, as described by Harding (2003). Specifically, to call a peak in any quarter it is required that real prices have risen over a period of at least six quarters and subsequently have fallen over a period of at least six quarters. Only "major" upswings are considered, with the cumulative real price increase from trough to peak to equal at least 15%. While necessarily *ad hoc*, the 15% criterion has been employed in earlier studies in this field (see Helbling, 2005). In this way, local peaks are avoided. The key results of the procedure for the 17 countries covered here are the following:

- Using this procedure, 36 peaks are identified, of which 12 were in the 1970s, 15 in the 1980s, seven in the 1990s and two in the current decade (Table 2 and Figure 3).[5] The number of peaks per country is thus relatively small, reflecting the long duration of housing cycles -- of the order of 10 to 15 years.

Figure 3. The number of housing peaks by country

From 1970Q1 to 2005Q4



5 . Korea, which was included in Girouard *et al.* (2006), is excluded here due to more limited data availability.

Table 2. Dating of peaks in real house prices

Period	Country	Date of peak[1]	Duration of upswing (quarters)	Price increase (%) Total	per annum	Followed by a major downturn[2]
1970s	United Kingdom	1973Q3	14	65%	4.6%	yes
	Switzerland	1973Q3	14	18%	1.3%	yes
	Japan	1973Q4	15	57%	3.8%	yes
	Australia	1974Q1	16	36%	2.3%	no
	Finland	1974Q2	10	24%	2.4%	yes
	New Zealand	1974Q3	18	63%	3.5%	yes
	Spain	1974Q3	14	28%	2.0%	no
	Canada	1976Q4	27	46%	1.7%	yes
	Netherlands	1978Q2	33	98%	3.0%	yes
	Spain	1978Q2	8	29%	3.6%	yes
	Denmark	1979Q2	37	32%	0.9%	yes
	Sweden	1979Q3	22	29%	1.3%	yes
1980s	United Kingdom	1980Q1	11	28%	2.5%	no
	France	1981Q1	44	31%	0.7%	yes
	Italy	1981Q1	44	98%	2.2%	yes
	Germany	1981Q2	20	16%	0.8%	yes
	Ireland	1981Q3	46	54%	1.2%	yes
	New Zealand	1984Q2	14	33%	2.4%	no
	Denmark	1986Q1	13	57%	4.4%	yes
	Norway	1986Q4	12	56%	4.7%	yes
	Canada	1989Q1	16	67%	4.2%	no
	Australia	1989Q1	8	36%	4.5%	no
	Finland	1989Q1	40	112%	2.8%	yes
	New Zealand	1989Q1	9	15%	1.7%	no
	United Kingdom	1989Q3	30	100%	3.3%	yes
	United States	1989Q4	23	17%	0.7%	no
	Switzerland	1989Q4	53	74%	1.4%	yes
1990s	Sweden	1990Q1	16	43%	2.7%	yes
	Ireland	1990Q2	12	28%	2.3%	no
	Japan	1991Q1	54	78%	1.4%	yes
	France	1991Q2	27	33%	1.2%	yes
	Spain	1991Q4	23	135%	5.9%	yes
	Italy	1992Q3	25	66%	2.6%	yes
	New Zealand	1997Q3	22	39%	1.8%	no
2000s	Finland	2000Q1	27	50%	1.9%	no
	Australia	2004Q1	32	85%	2.7%	no
	Average		24	52%	2.5%	

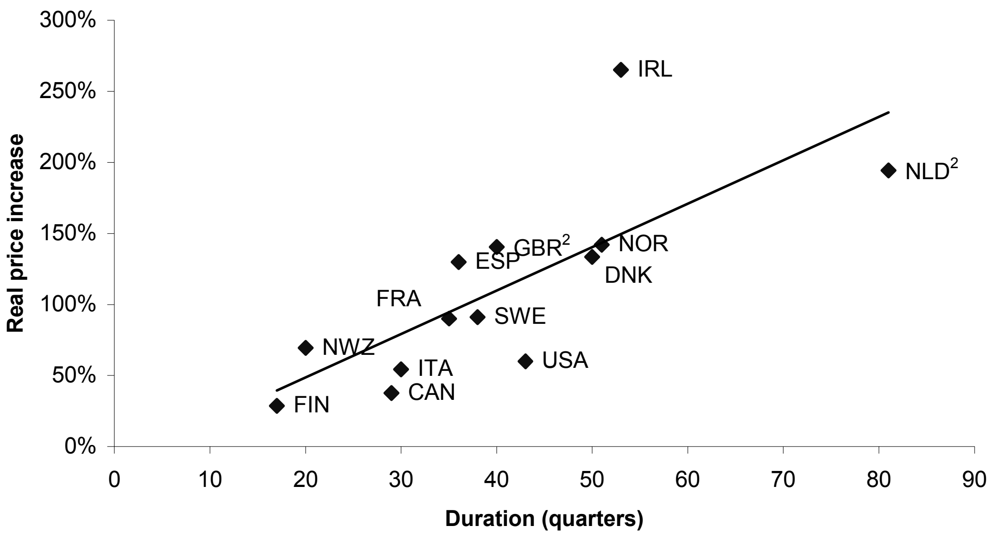
1. A peak is reached if following real prices fell over a period of at least six quarters following a major upswing. An upswing qualifies as "major" if real prices have risen over a period of at least six quarters and if the cumulative real price increase is at least 15%.
2. A downswing qualifies as "major" if the cumulative real price decline is at least 15%.

- Aside from New Zealand, where peaks have been most frequent (four in total) the distribution of peaks across countries is perfectly symmetric around an average of two over the sample period. Four countries (United Kingdom, Australia, Finland and Spain) have seen three peaks and another four countries (United States, Germany, the Netherlands and Norway) have seen one peak, while the remaining eight countries experienced two peaks over this period.

- In around two-thirds of the completed cycles, a peak was followed by a major downturn, *i.e.* a fall of at least 15% until the next trough. The majority of countries (13 in total, including six out of the seven major countries) are currently in a major upswing but have not yet reached a peak (Table 3, Figure 4). Real house prices in the United Kingdom and the Netherlands have substantially decelerated in recent years, but without satisfying the criterion of a peak.

11. The current upswing portrays two distinct features: its comparatively long duration and the extent of the real price gains. The real price gains observed so far amounts to over 100% as opposed to 50% for past upswings (as listed in Table 1) and the duration is almost twice that of the historical record (40 quarters on average as opposed to 24 quarters for past upswings). The extent of the Dutch and Irish upswings are particularly exceptional, albeit the former more in terms of its duration (over 20 years) and the latter more in terms of the size of the price gain (more than 250%). Therefore, any conclusion drawn from a probit analysis -- which is necessarily based on historical relationships -- needs to be interpreted with care. Even so, the presumption must be that the ongoing upswing will also at some point reach a peak.

Figure 4. The extent of the ongoing (but yet incomplete) upswings[1]



1. Up to and including the fourth quarter of 2005.

2. In the United Kingdom and the Netherlands real house prices have significantly decellerated.

Table 3. Incomplete major upswings to date[1]

Country[2]	Duration to date (quarters)	Real price increase (%) Total	per annum
Ireland	53	265%	10.3%
Netherlands[3]	81	194%	5.5%
Norway	51	142%	7.2%
United Kingdom[3]	40	140%	9.2%
Denmark	50	134%	7.0%
Spain	36	130%	9.7%
Sweden	38	91%	7.1%
France	35	90%	7.6%
New Zealand	20	69%	11.1%
United States	43	60%	4.5%
Italy	30	54%	5.9%
Canada	29	38%	4.5%
Finland	17	29%	6.1%
Average	40	110%	7.7%

1. An upswing qualifies as "major" if real prices have risen over a period of at least six quarters and the cumulative increase is at least 15%. The last observation included is for the fourth quarter of 2005.
2. Ranked according to the cumulative increase in real prices.
3. In the United Kingdom and the Netherlands real house prices have substantially decelerated.

12. Finally, in order to make the probit model of any use for prediction purposes, it needs to be forward-looking. Therefore the relevant event is not the peak itself, but its occurrence in the near-term future, *e.g.* within the next four quarters. Using this criterion, the dating procedure yields a matrix with elements $E_{i,t}$ that for any country i take a value 1 in quarter t if in the four subsequent quarters, $t+1$ until $t+4$, a peak is called and otherwise take a value 0. The dependent variable in the probit model is then the probability P_{it} of a house price peak occurring in the next four quarters.

Pooled estimation results

13. The model presented in this section was estimated on a pool containing all 17 countries covered in this paper. A variety of explanatory variables were considered, including long and short-interest rates (entered in either real or nominal terms), the inflation rate, the unemployment rate, the current account balance, the share of residential investment in GDP, the rate of change in real house prices in the recent past, the gap of the real house price index against its long-term trend and the rate of change in the country-specific equity price index. In the final regression most variables were dropped because their coefficients were insignificant, and only three were retained: the nominal long-term interest rate (*IRL*, entered as its inverse), the real house price gap defined as the difference between the logarithm of the real house price index (*log HPR*) and the log-linear trend of the real house price index ($log\ HPR^T$), and the two-quarter moving average of the rate of change in real house prices (standard errors are in brackets). The estimated equation reads:

$$Z_{it} = F^{-1}(P_{it}) =$$

(1)
$$\underset{(0.13)}{-0.99} - \underset{(1.05)}{8.13}\frac{1}{IRL_{it}} + \underset{(0.36)}{3.24}\left(\log HPR_{it} - \log HPR_{it}^{T}\right) + \underset{(2.06)}{21.09}\left(\Delta \log HPR_{it} + \Delta \log HPR_{it-1}\right)/2$$

McFadden R^2 = 0.287
Mean dependent var. = 0.06;
s.d. dependent var. = 0.239
s.e. of regression = 0.215
Sum squared residuals = 108.56
No. of observations = 2360,
of which dependent variable 1 = 144 and 0 = 2216.

14. All coefficients are significant at the 1% level and have the expected sign. Aside from its statistical significance, the rationale for retaining the nominal (as opposed to the real) long-term interest rate is that it is closely related to financing constraints in the short run, such as the proportion of income absorbed by interest payments, the ability to borrow and the willingness to lend.[6] The rationale for including the nominal interest rate *as its inverse* is to mimic the strongly non-linear impact on financing constraints: everything else equal, the borrowing cost roughly doubles after an increase in the rate from 2% to 4% while it increases by only 50% if the rate rises from 4% to 6% (in fact the difference will be larger to the extent that prices and loan-to-value ratios are higher in the former case).[7] The other two retained variables are controls for overheating and should be considered together. A strong rate of growth of house prices following a trough would not, by itself, be a sign of overheating. However, if it occurs in conjunction with a large, above-trend gap of house prices, this could be a sign that these markets may indeed be overheated.

15. The estimated coefficients capture the impact of the explanatory variables on the latent variable Z_{it}, not on the probabilities P_{it}. To gauge the latter, the convention is to compute the marginal probabilities from the cumulative standard normal distribution for the point on the distribution that corresponds to the sample means of the explanatory variables. However, since the focus here is on the marginal probabilities at the end of the sample period for each individual country, rather than at the sample average, a different approach was followed. Computations were carried out in which increases in interest rates by 100 and 200 basis points were superimposed on the observed rates in the fourth quarter of 2005. The simulations were run for two cases, one in which the real house prices were held constant at their estimated levels in the fourth quarter of 2005, and one in which real house prices were assumed to rise in 2006 at the same rate as in 2005. The latter provides a rough and ready estimate of the increase in the exposure to interest rate shocks, assuming that the housing upswing proceeds further. The results are reported in Table 4 and Figure 5 and can be summarized as follows:

- By the end of 2005, the probabilities of the upturn ending in the next four quarters -- *i.e.* in 2006 -- were generally lower than 25%, with the exception of New Zealand, where the probability was slightly over 25%.

- If interest rates rise by 100 basis points from their late-2005 levels, the probability of a housing peak occurring in 2006 is estimated to be above 25% also in Denmark. For an increase in interest rates by 200 basis points Ireland and Sweden would also breach a 25% probability.8

- If real house prices are assumed to increase further in 2006 at their average 2005 rate and interest rates rose by 100 basis points, a peak would occur with a probability of 50% or higher in France,

6. Borio and McGuire (2004) also find that the nominal interest rate is significant. This feature of the housing market is confirmed in a micro probit-study for the United Kingdom by May and Tudela (2005).

7 . See Himmelberg *et al.* (2005).

8. When this paper was finalised interest rates had already risen by roughly 50 basis points since the fourth quarter of 2005.

Denmark, New Zealand and Sweden in 2007. If interest rates rose by 200 basis points, a probability of 50% or more would also be reached in the United States and Spain while it would be a close call for Ireland.

16. These results need to be qualified on at least one count. The performance of the model in predicting *ex post* the peaks that occurred in most countries during the estimation period is shown in Annex I. Apparently, the model is better at predicting large peaks that usually occur in countries with comparatively volatile real house prices, such as for instance the United Kingdom and several smaller countries. However, it performs less well at predicting the end of less pronounced (but still major) upswings that typically occur in the largest economies (notably the United States).[9]

Table 4. Probabilities of real house prices nearing a peak: pooled regressions

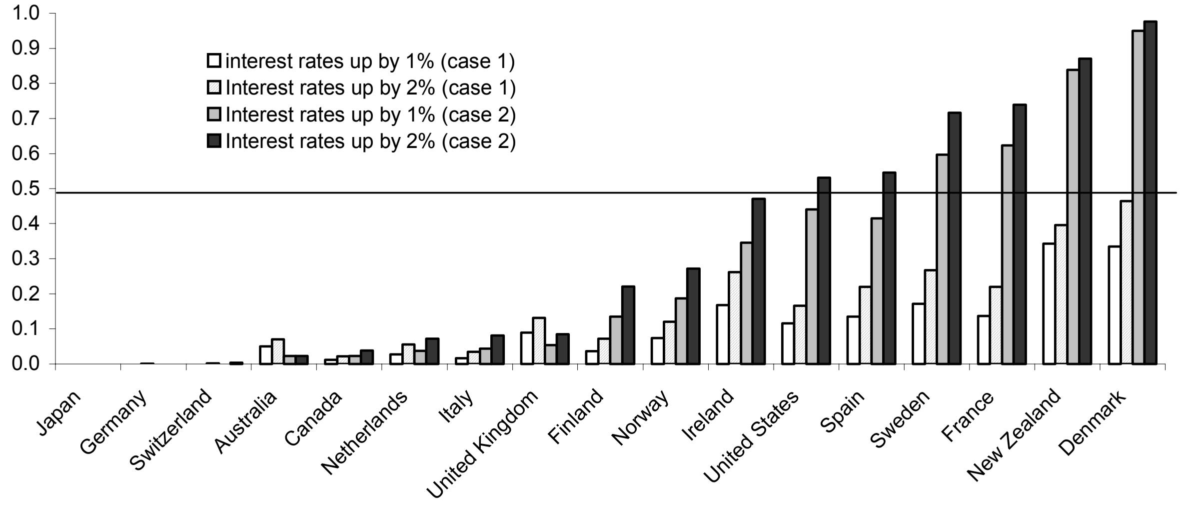
	Situation in fourth quarter of 2005			Probability of a peak after an increase in interest rates by		Probability of a peak after an increase of the real house price in 2006 at the same rate as in 2005 in each country and an increase in interest rates by	
	Real house price gap (%)	Interest rate (%)[1]	Probability of a peak	1%	2%	1%	2%
United States	26	4.5	0.064	0.115	0.165	0.441 *	0.531 **
Japan	-33	1.5	0.000	0.000	0.000	0.000	0.000
Germany	-13	3.4	0.000	0.000	0.001	0.000	0.000
France	34	3.5	0.054	0.136	0.220	0.624 **	0.739 **
Italy	26	3.6	0.004	0.016	0.034	0.043	0.081
United Kingdom	31	4.4	0.046	0.089	0.132	0.054	0.084
Canada	11	4.2	0.004	0.011	0.021	0.022	0.039
Australia	22	5.3	0.029	0.049	0.070	0.022	0.022
Denmark	40	3.4	0.168	0.335 *	0.465 *	0.951 ***	0.977 ***
Finland	20	3.4	0.010	0.036	0.072	0.135	0.221
Ireland	45	3.5	0.070	0.168	0.262 *	0.345 *	0.471 *
Netherlands	27	3.5	0.007	0.027	0.056	0.036	0.072
New Zealand	37	6.1	0.278 *	0.343 *	0.396 *	0.839 ***	0.871 ***
Norway	29	3.9	0.030	0.073	0.120	0.187	0.271 *
Spain	34	3.5	0.053	0.135	0.219	0.416 *	0.546 **
Sweden	38	3.5	0.072	0.171	0.267 *	0.597 **	0.716 **
Switzerland	-4	2.0	0.000	0.000	0.002	0.000	0.003

1. Long-term bond yield.

Note: *, **, *** denote probabilities over 25%, 50% and 75%, respectively.

9. This may simply reflect that in larger countries the aggregate housing cycle is smoother due to greater cross-regional heterogeneity than in smaller countries. As a result the estimation may be biased.

Figure 5. The probability of real house prices nearing a peak (pooled model)



Note: Case 1 refers to the situation in which the interest rate shock kicks in at real house prices as observed in the fourth quarter of 2005. Case 2 assumes that real house prices further increase (or decrease) at the pace observed in 2005 for another year in each country before the interest rate shock kicks in. To call a peak it is required that real prices fall over a period of at least six quarters after having risen by at least 15% cumulatively over a period of six quarters.

Country-specific models

17. The fact that the pooled regression model imposes uniformity on the conditional probability responses to the explanatory variables across countries may be considered as a handicap. In theory this can be remedied by estimating the model on a country-by-country basis. However, this comes with other drawbacks, most prominently the fact that the number of observed peaks in each country is small and therefore the robustness of the results questionable. There is also an associated risk of data mining, with the quest for the best fit possibly resulting in a model that attributes large predictive power to a constellation of explanatory factors that more or less accidentally accompanied the few observed peaks. Therefore, at best, individual country estimates should be seen as complementing rather than replacing the pooled results. The results reported below should be considered with these caveats in mind.

18. To estimate the individual country models, the following procedure was used. As a first step, the model as presented in Equation (1) was re-estimated for each individual country. Subsequently, experiments were carried out with a view to improving the performance of each individual country model. There were a few cases where the specification used in the pooled model also proved optimal for the individual country models (Spain and Switzerland). In all other cases the specification was changed in a number of ways (Table 5):

- In several cases entering the *inflation rate* as an additional explanatory variable improved the equation significantly (United States, France, Denmark, New Zealand and Sweden). This variable enters the equation with a negative sign, suggesting that higher inflation eases the financing constraint facing households and therefore makes a peak less likely.

Table 5. Regression results by country

Explanatory variable/ country	1/interest rate	Real house price gap	Real house price increase, 2Q moving average	Other explanatory variables (sign)	McFadden R^2
United States	simple average of short and long rate **	yes **		Inflation (-) **	0.531
Japan	long rate *	yes ***		Δshare of residential investment in GDP (+) **	0.597
Germany		yes **			0.617
France	long rate ***	yes **	yes *	Inflation 2Q moving average (-) **	0.734
Italy	long rate, 3Q moving average **			Δ share of residential investment in GDP (+) ** Δ unemployment rate, 4Q moving average (-) ** Δ household saving ratio, 3Q moving average (-) ***	0.570
United Kingdom	short rate, 5Q moving average **	yes *	yes ***		0.718
Canada	long rate, 3Q moving average **			share of residential investment in GDP (+) ***	0.519
Australia	real long rate, 3Q moving average **	yes **	yes, no moving average ***	Δ unemployment rate (-) **	0.506
Denmark	long rate **	yes ***		inflation (-) ** unemployment rate (+) **	0.592
Finland	real long rate ***	yes ***		Δ share of residential investment in GDP, 2Q moving average (+) *** Δ log equity index (+) ***	0.531
Ireland	short rate **		yes **		0.386
Netherlands	long rate, 3Q moving average(-5) *		yes **	share of residential investment in GDP (+) **	0.651
New Zealand	long rate ***	yes ***	yes ***	Inflation (-) ** Δ log equity index, 4Q lag (-) **	0.368
Norway	long rate, 3Q moving average (-3) **			Δ share of residential investment in GDP (+) ** inflation(-) *	0.671
Spain	long rate ***	yes ***	yes **		0.457
Sweden	long rate **	yes ***	yes **	Inflation (-) **	0.820
Switzerland	long rate **	yes **	yes ***		0.697

Note: *, **, *** denote significance at 10%, 5% and 1%, respectively. See Annex II for further information on the regression statistics.

- In a number of cases the equation was improved by entering the *share of residential investment in GDP*, either as its level (Canada, Netherlands) or as its change (Japan, Italy, Finland and Norway). The sign is always positive, indicating that an increase in housing supply may contribute to the likelihood that a peak is nearing.

- The change in the *unemployment rate*, which may be interpreted as an indicator of the overall business cycle, proved significant in the equations of two countries (Italy and Australia). The sign is negative, suggesting that house prices behave pro-cyclically in these countries. In one country (Denmark) the unemployment rate appeared as its level, and with a positive sign, indicating that the trend decline in unemployment since the early 1990s has diminished the likelihood of house prices peaking.

- Financial variables that proved significant in a few cases were the change in the *household saving ratio* (Italy) and the rate of change in the *local equity index* (Finland and New Zealand).

19. In some cases the interest rate term needed to be modified. In several cases the short-term interest rate was found to be important, either instead of the long rate (United Kingdom, Ireland), or in addition to it (United States). In some cases the real interest rate clearly outperformed the nominal rate (Australia and Finland) or lags proved necessary (Italy, United Kingdom, Canada, the Netherlands, Norway and Australia). In one case the interest rate entirely dropped out of the equation (Germany).[10] In five cases the same happened with regard to the price gap (Italy, Canada, Ireland, Netherlands, Norway while the rate of change in the real house price was retained in nine cases (France, United Kingdom, Australia, Ireland, Netherlands, New Zealand, Spain, Sweden and Switzerland).

20. All this suggests a large degree of cross-country heterogeneity, which the pooled model failed to capture to a large extent. This is confirmed by the *ex post* performance of the country-specific models in predicting housing peaks, which is clearly superior in most cases (Annex I). Carrying out the same simulation exercise, *i.e.* of increases in interest rates by 100 and 200 basis points superimposed on the current levels of interest rates in 2005Q4, yields the following main findings (Table 6):

- The risk of the housing upswing nearing a peak, even without further interest rate hikes, is found to be high (at or close to 100%) in the United States, and smaller but still significant (>25%) in France and New Zealand.

- A rise in interest rates by 100-200 basis points -- either kicking in immediately or after a further increase in real house prices in 2006 at the rate observed in 2005 -- would suffice to raise the probability of a peak to (or close to) one in the United States, France, Denmark, Ireland, New Zealand, Spain and Sweden. Importantly, this is the same group of countries that also emerged as being at risk of a peak on the basis of the pooled model.

Concluding remarks

21. Both sets of estimates (pooled and individual) point to the same group of countries as being at risk of nearing a peak if interest rates significantly increase from their levels observed in the fourth quarter of 2005: the United States, France, Denmark, Ireland, New Zealand, Spain and Sweden. This prediction is conditional on the development of interest rates and it also depends on the validity of the historical relationships as estimated. The fact that the current upswing has been rather different from the historical experience in a number of respects -- the long duration of the upswing, the extent of the observed price increases, their cross-country simultaneity and disconnection from the overall business cycle in a number of cases -- calls for some caution concerning the relevance of the historical relationships. Even so, housing activity indicators such as stock-to-sales ratios for the biggest housing market in the sample -- that of the United States -- have been weakening recently. This suggests that forces may be at work that could eventually result in a downturn in real house prices in that country in response to recent and further increases in interest rates, as predicted by the probit models. The fact that in Europe some major housing markets (France, Spain) are also at risk of peaking may raise concerns over the strength of the cyclical recovery of the euro area going forward. The recent cooling of the UK and Australian housing markets suggests that monetary policy may be instrumental in orchestrating a soft landing. However, this is less obvious in the euro area, where monetary policy is necessarily geared towards area-aggregate performance.

10. This may reflect the very long loan terms (25-30 years).

Table 6. Probabilities of real house prices nearing a peak: country-by-country regressions

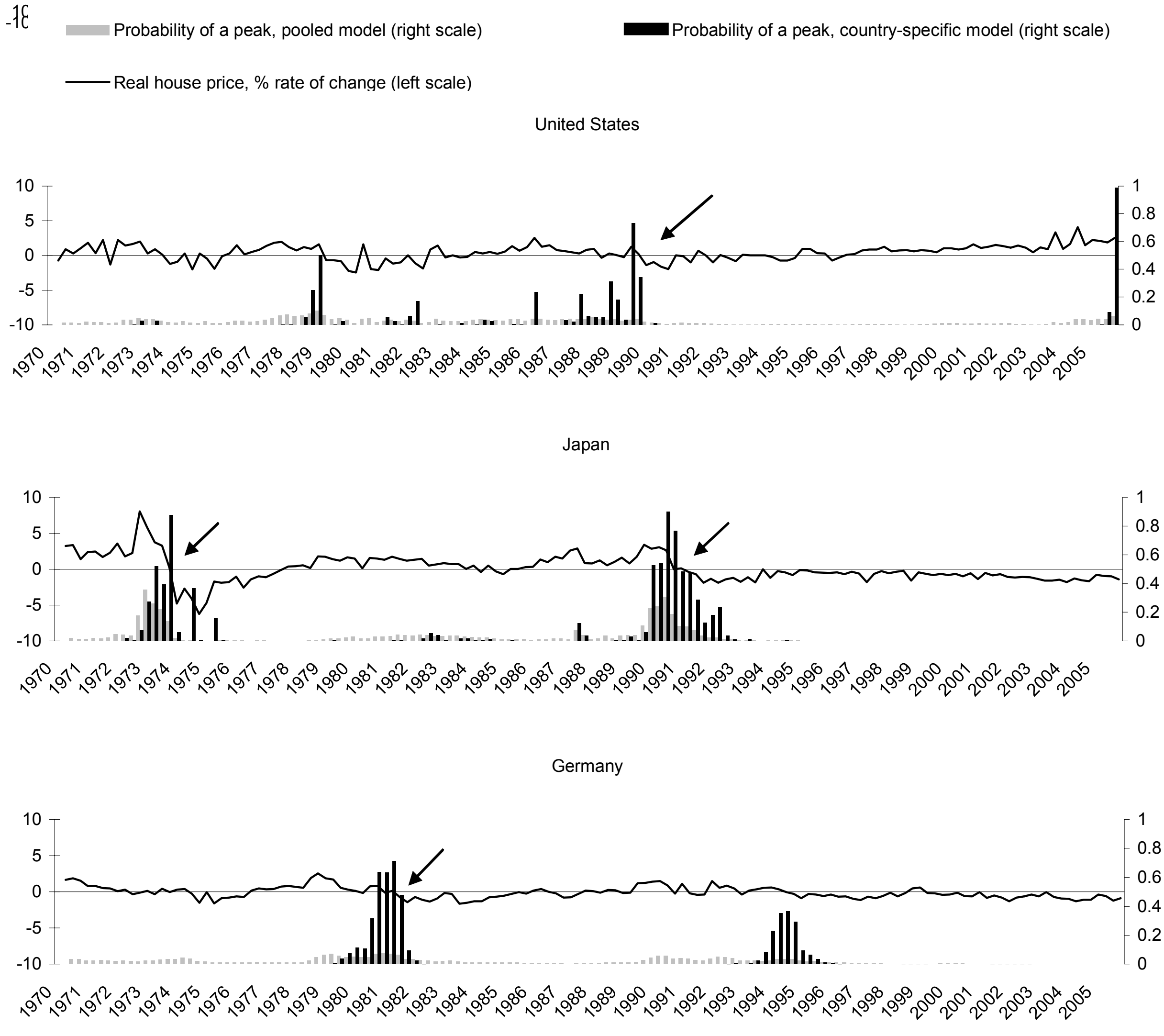
	Situation in fourth quarter of 2005				Probability of a peak after an increase in interest rates by				Probability of a peak after an increase of the real house price in 2006 at the same rate as in 2005 in each country and an increase in interest rates by			
	Real house price gap (%)	Interest rate (%)[1]	Probability of a peak		1%		2%		1%		2%	
United States	26	4.4	0.985	***	1.000	***	1.000	***	1.000	***	1.000	***
Japan	-33	1.5	0.000		0.000		0.000		0.000		0.000	
Germany	-13	3.4	0.000		0.000		0.000		0.000		0.000	
France	34	3.5	0.355	*	1.000	***	1.000	***	1.000	***	1.000	***
Italy	26	3.5	0.000		0.000		0.000		0.000		0.000	
United Kingdom	31	4.7	0.000		0.000		0.000		0.000		0.000	
Canada	11	4.0	0.000		0.000		0.000		0.000		0.000	
Australia	22	3.2	0.043		0.045		0.047		0.007		0.007	
Denmark	40	3.4	0.024		0.783	***	0.994	***	1.000	***	1.000	***
Finland	20	1.4	0.055		0.057		0.057		0.083		0.084	
Ireland	45	2.2	0.000		1.000	***	1.000	***	1.000	***	1.000	***
Netherlands	27	4.2	0.000		0.000		0.000		0.000		0.000	
New Zealand	37	6.1	0.638	**	0.663	**	0.821	***	0.995	***	0.999	***
Norway	29	4.4	0.000		0.000		0.000		0.000		0.000	
Spain	34	3.5	0.023		0.143		0.317	*	0.600	**	0.800	***
Sweden	38	3.5	0.000		0.000		0.003		0.937	***	1.000	***
Switzerland	-4	2.0	0.000		0.000		0.000		0.000		0.000	

1. As entered in the equations, see Annex II.

Note: *, **, *** denote probabilities over 25%, 50% and 75%, respectively

ANNEX I

Figure A.1. Ex post prediction of peaks in real house prices[1]



1. The arrows indicate peaks

Figure A.1. (continued) Predicting housing price peaks ex post

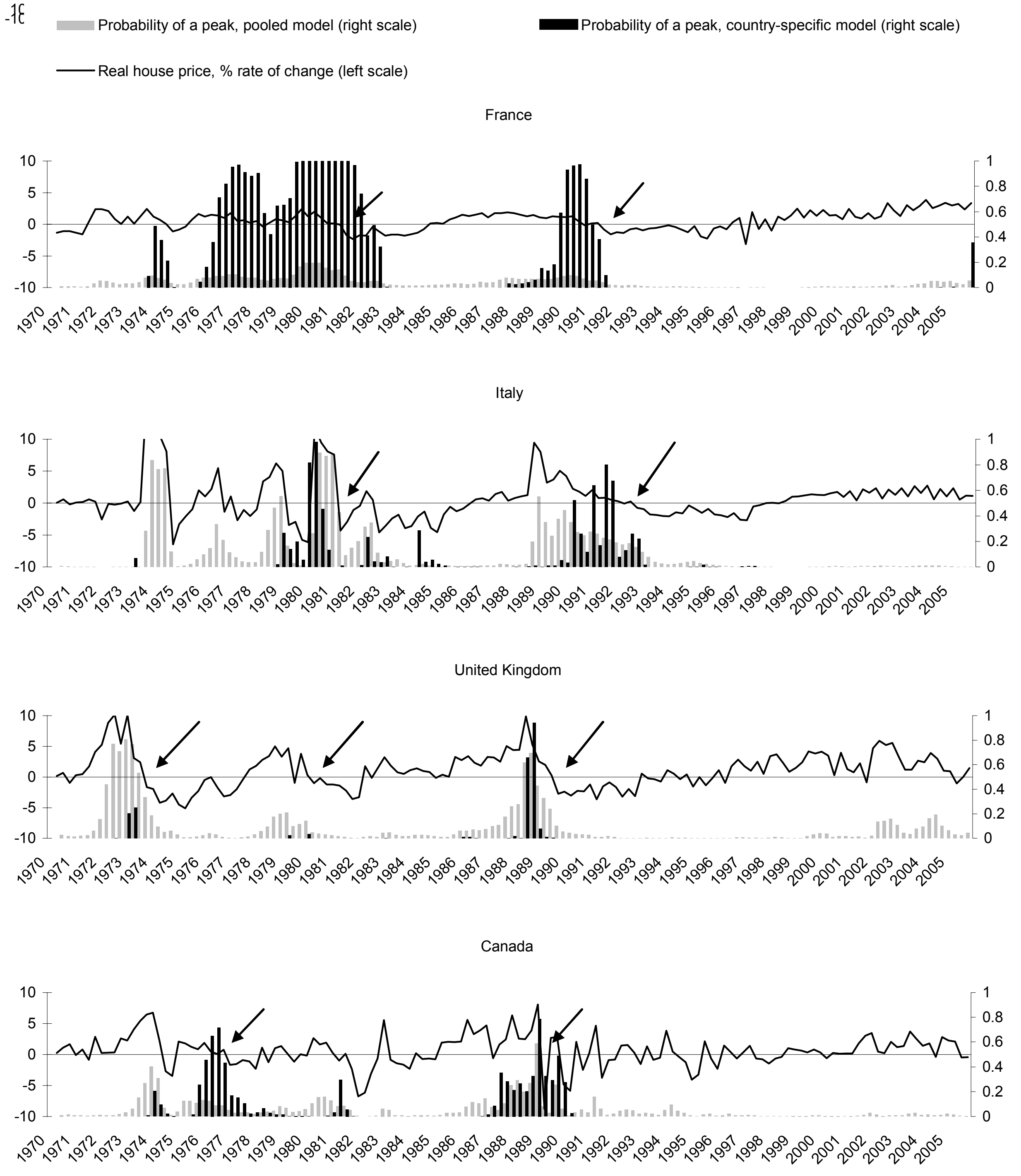


Figure A.1. (continued) Predicting housing price peaks ex post

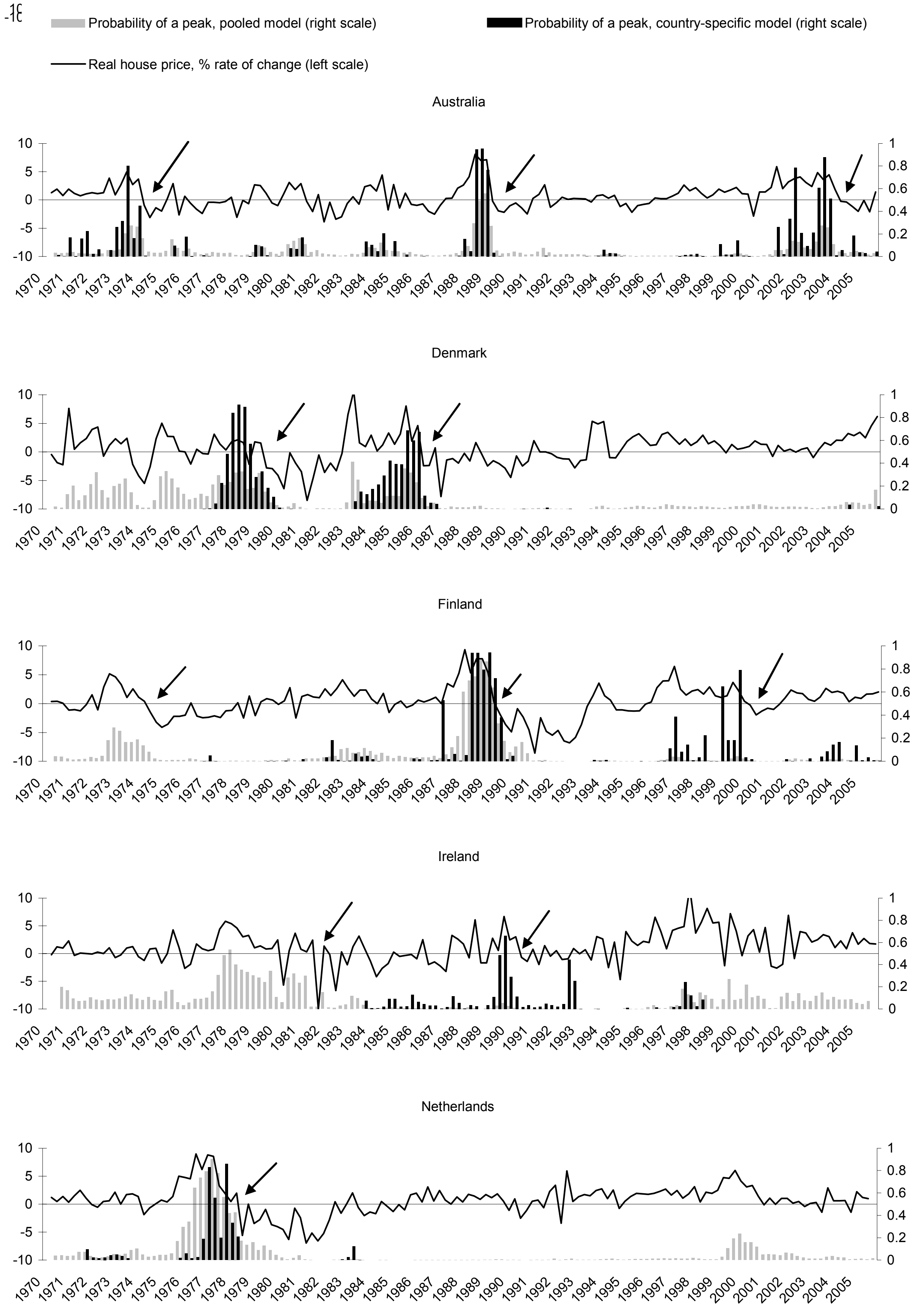
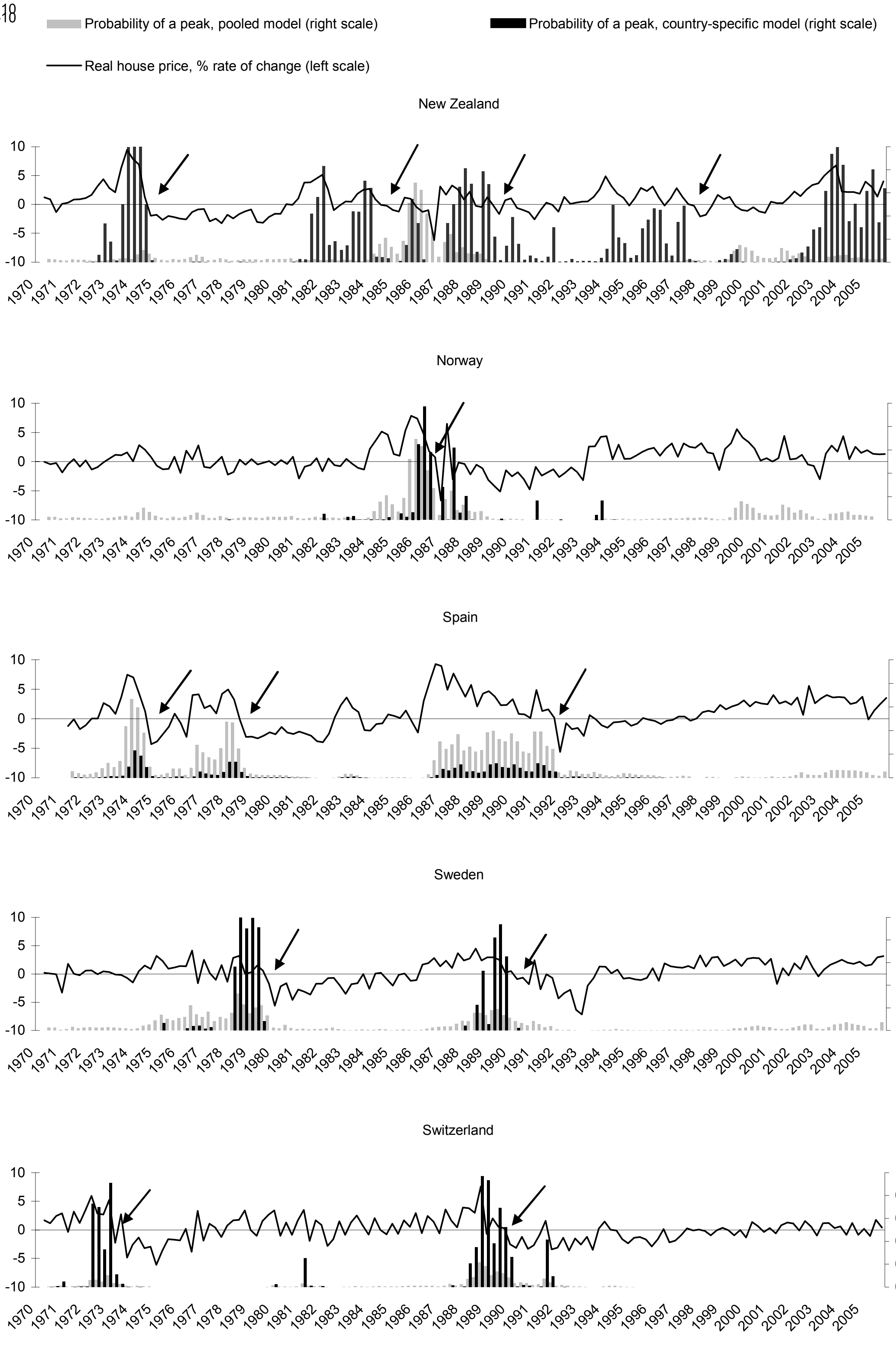


Figure A.1. (continued) Predicting housing price peaks ex post



ANNEX II:
ESTIMATION RESULTS BY COUNTRY

22. The estimation strategy can be summarised as follows. As a first shot, a benchmark model whose specification is identical to the pooled model was estimated. This was subsequently modified by dropping or adding explanatory variables where this improved the model's performance. For example, in some cases it appeared better to use the short-term interest rate (United Kingdom, Ireland) and in other cases it helped to add supply variables (residential investment as a share of GDP), financial variables (household saving ratio) or inflation. These results are briefly discussed below. The following mnemonics are used:

C	Constant term
EQUITY	Stock market index
INFL	Inflation rate (annualised, based on private consumption deflator)
IRL	Long-term bond yield
IRS	Short-term interest rate
LNRHP	Log of real house price index
LNTRENDRHP	Logarithmic trend of real house price index
IHQ	Share of residential investment in GDP
SRATIO	Household saving ratio
UNR	Unemployment ratio

United States

23. The benchmark model performed comparatively poorly for the United States, yet it proved relatively straightforward to estimate a US-specific model that did perform acceptably. Removing past real house price increases, replacing the long-term interest rate with the arithmetic average of the long and short rates and adding the rate of inflation provided the best results, with all explanatory variables significant at the 5% level. Obviously, with only one peak detected, the robustness of these results is very limited.

Estimation results: United States

Variable	*Coefficient*	*Std. Error*	*z-Statistic*	*Prob.*
C	10.002	5.014	1.995	0.046
2/(IRL+IRS)	-72.513	34.287	-2.115	0.034
LNRHP-LNTRENDRHP	43.298	18.429	2.349	0.019
INFL	-0.962	0.422	-2.281	0.023
Mean dependent var	0.028	S.D. dependent var		0.166
S.E. of regression	0.136	Akaike info criterion		0.177
Sum squared resid	2.571	Schwarz criterion		0.260
Log likelihood	-8.538	Hannan-Quinn criter.		0.210
Restr. log likelihood	-18.221	Avg. log likelihood		-0.060
LR statistic (3 df)	19.367	McFadden R-squared		0.531
Probability(LR stat)	0.000			
Obs with Dep=0	138	Total obs		142
Obs with Dep=1	4			

Japan

24. In Japan the past real house price increase variable dropped out at as an explanatory variable, whereas residential investment as a share of GDP (or rather its change) appeared to be a relatively powerful predictor. Otherwise the benchmark model could be maintained. The *ex post* performance of the model is reasonable, and certainly much better than that of the base-line model, especially in predicting the early-1990s peak.

Estimation results: Japan

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	1.026	2.209	0.465	0.642
1/IRL	-26.870	15.180	-1.770	0.077
LNRHP-LNTRENDRHP	11.466	3.303	3.471	0.001
D(IHQ)	2.555	1.257	2.033	0.042
Mean dependent var	0.057	S.D. dependent var		0.233
S.E. of regression	0.170	Akaike info criterion		0.234
Sum squared resid	3.935	Schwarz criterion		0.318
Log likelihood	-12.345	Hannan-Quinn criter.		0.268
Restr. log likelihood	-30.665	Avg. log likelihood		-0.088
LR statistic (3 df)	36.639	McFadden R-squared		0.597
Probability(LR stat)	0.000			
Obs with Dep=0	132	Total obs		140
Obs with Dep=1	8			

Germany

25. The German model is among the least satisfactory ones, perhaps due to the uncertain quality of German house price series (see Deutsche Bundesbank, 2003). It proved hard to detect an impact of any economic variable, be it interest rates, the unemployment rate or residential construction activity. In fact, the only explanatory variable that proved significant was the real house price gap. This variable did have a relatively strong *ex post* predictive power, but this is hardly surprising given the way it is constructed (a strong positive gap will always be indicative of a peak) and the fact that only one peak has been detected.

Estimation results: Germany

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-8.632	3.444	-2.506	0.012
LNRHP-LNTRENDRHP	92.717	39.911	2.323	0.020
Mean dependent var	0.029	S.D. dependent var		0.167
S.E. of regression	0.129	Akaike info criterion		0.128
Sum squared resid	2.294	Schwarz criterion		0.170
Log likelihood	-6.962	Hannan-Quinn criter.		0.145
Restr. log likelihood	-18.164	Avg. log likelihood		-0.050
LR statistic (1 df)	22.404	McFadden R-squared		0.617
Probability(LR stat)	0.000			
Obs with Dep=0	136	Total obs		140
Obs with Dep=1	4			

France

26. The French case fitted the benchmark model fairly well, but it proved possible to enhance its predictive power by adding inflation as an explanatory variable (as a two-quarter moving average). The long-term interest rate and the price gap are both highly significant. The model accurately picks up the late 1970s and late-1980s peaks, in the latter case with a comfortable lead time.

Estimation results: France

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	5.587	2.458	2.273	0.023
1/IRL	-93.431	32.818	-2.847	0.004
LNRHP-LNTRENDRHP	51.182	21.111	2.424	0.015
((RHP/RHP(-1)-1)+(RHP(-1)/RHP(-2)-1))/2	106.968	62.089	1.723	0.085
(INFL+INFL(-1))/2	-0.455	0.187	-2.430	0.015
Mean dependent var	0.058	S.D. dependent var		0.234
S.E. of regression	0.144	Akaike info criterion		0.189
Sum squared resid	2.795	Schwarz criterion		0.295
Log likelihood	-8.147	Hannan-Quinn criter.		0.232
Restr. log likelihood	-30.606	Avg. log likelihood		-0.059
LR statistic (3 df)	44.916	McFadden R-squared		0.734
Probability(LR stat)	0.000			
Obs with Dep=0	131	Total obs		139
Obs with Dep=1	8			

Italy

27. For Italy the benchmark model failed completely and some major modifications were necessary. Long-term interest rates were entered with a distributed lag, the price gap and past price increases were removed, and distributed lags of the changes in the unemployment rate, the household saving ratio and residential investment as a share of GDP were included. This tailor-made model accurately predicts the early 1980s and early-1990s peaks with convenient lead times.

Estimation results: Italy

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	2.640	1.711	1.543	0.123
3/(IRL+IRL(-1)+IRL(-2))	-63.450	26.466	-2.397	0.017
(D(UNR)+D(UNR(-1))+D(UNR(-2))+D(UNR(-3)))/4	-4.322	2.036	-2.123	0.034
(D(SRATIO)+D(SRATIO(-1))+D(SRATIO(-2)))/3	-3.821	1.378	-2.774	0.006
D(IHQ(-1))	8.212	3.448	2.382	0.017
Mean dependent var	0.058	S.D. dependent var		0.235
S.E. of regression	0.174	Akaike info criterion		0.263
Sum squared resid	4.040	Schwarz criterion		0.369
Log likelihood	-13.137	Hannan-Quinn criter.		0.306
Restr. log likelihood	-30.546	Avg. log likelihood		-0.095
LR statistic (4 df)	34.818	McFadden R-squared		0.570
Probability(LR stat)	5.06E-07			
Obs with Dep=0	130	Total obs		138
Obs with Dep=1	8			

United Kingdom

28. As may be expected given the large share of variable mortgage interest rates, the short-term interest rate performed better than the long-term rate, albeit with a five-quarter moving average. Past real house price increases and the real house price gap both could be retained in their base-line model form. Past peaks are accurately predicted, and much better so than with the pooled model (which completely misses the late-1970s peak).

Estimation results: United Kingdom

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	4.275	2.793	1.531	0.126
5/(IRS+IRS(-1)+IRS(-2)+IRS(-3)+IRS(-4))	-92.026	43.397	-2.121	0.034
((RHP/RHP(-1)-1)+(RHP(-1)/RHP(-2)-1))/2	109.991	42.397	2.594	0.010
LNRHP-LNTRENDRHP	4.359	2.294	1.900	0.057
Mean dependent var	0.087	S.D. dependent var		0.283
S.E. of regression	0.166	Akaike info criterion		0.225
Sum squared resid	3.712	Schwarz criterion		0.309
Log likelihood	-11.497	Hannan-Quinn criter.		0.259
Restr. log likelihood	-40.771	Avg. log likelihood		-0.083
LR statistic (3 df)	58.548	McFadden R-squared		0.718
Probability(LR stat)	0.000			
Obs with Dep=0	126	Total obs		138
Obs with Dep=1	12			

Canada

29. In Canada the benchmark model broke down completely. A simpler specification, with a three-year moving average of the long-term interest rate (in Canada, households have a wide variety of mortgage terms to choose from) and the share of residential investment in GDP worked reasonably well. Both variables have significant coefficients at the 5% level (1% in the case of residential investment). The two peaks in the sample are captured, although without much of a lead time in the case of the second peak.

Estimation results: Canada

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-15.071	6.007	-2.509	0.012
3/(IRL+IRL(-1)+IRL(-2))	-64.179	32.154	-1.996	0.046
IHQ	2.991	1.071	2.793	0.005
Mean dependent var	0.057143	S.D. dependent var		0.232
S.E. of regression	0.192	Akaike info criterion		0.253
Sum squared resid	5.044	Schwarz criterion		0.317
Log likelihood	-14.744	Hannan-Quinn criter.		0.279
Restr. log likelihood	-30.665	Avg. log likelihood		-0.105
LR statistic (2 df)	31.841	McFadden R-squared		0.519
Probability(LR stat)	0.000			
Obs with Dep=0	132	Total obs		140
Obs with Dep=1	8			

Australia

30. Australia is one of the rare cases where real rather than nominal interest rates are a predictor of a housing peak. Even so, the real interest rate is not a very powerful predictor (it is significant at 10%). Other, more significant, predictors are the past quarter real house price increase, the real house price gap and the change in the unemployment rate. The model does a reasonable job predicting the three peaks in the sample, including the one that was observed in 2004Q1.

Estimation results: Australia

Variable	*Coefficient*	*Std. Error*	*z-Statistic*	*Prob.*
C	-3.049	0.631	-4.828	0.000
3/(IRL-INFL+IRL(-1)-INFL(-1)+IRL(-2)-INFL(-2))	-0.356	0.191	-1.861	0.063
LNRHP-LNTRENDRHP	4.534	1.899	2.388	0.017
RHP/RHP(-1)-1	48.298	13.632	3.543	0.000
D(UNR)	-2.763	1.338	-2.065	0.0389
Mean dependent var	0.086	S.D. dependent var		0.281
S.E. of regression	0.216	Akaike info criterion		0.360
Sum squared resid	6.299	Schwarz criterion		0.465
Log likelihood	-20.220	Hannan-Quinn criter.		0.403
Restr. log likelihood	-40.951	Avg. log likelihood		-0.144
LR statistic (4 df)	41.463	McFadden R-squared		0.506
Probability(LR stat)	2.15E-08			
Obs with Dep=0	128	Total obs		140
Obs with Dep=1	12			

Denmark

31. Denmark partially fits the benchmark model. The price gap is significant, but not the pace of the real price increase. Additional significant variables are the unemployment rate and the inflation rate. Most explanatory variables are strongly significant, and the fit is satisfactory.

Estimation results: Denmark

Variable	*Coefficient*	*Std. Error*	*z-Statistic*	*Prob.*
C	-5.256	3.462	-1.518	0.129
1/IRL	-41.440	16.622	-2.493	0.013
LNRHP-LNTRENDRHP	21.837	7.669	2.847	0.004
UNR	1.459	0.592	2.464	0.014
INFL	-0.400	0.193	-2.071	0.038
Mean dependent var	0.057	S.D. dependent var		0.233
S.E. of regression	0.176	Akaike info criterion		0.250
Sum squared resid	4.168	Schwarz criterion		0.355
Log likelihood	-12.515	Hannan-Quinn criter.		0.293
Restr. log likelihood	-30.665	Avg. log likelihood		-0.089
LR statistic (3 df)	36.299	McFadden R-squared		0.592
Probability(LR stat)	0.000			
Obs with Dep=0	132	Total obs		140
Obs with Dep=1	8			

Finland

32. For Finland the benchmark model broke down. Residential investment and the stock market index successfully entered the equation whereas past house price increases dropped out. In stead of the nominal interest rate, the real interest rate worked, but the coefficient, though significant, is very small. Unlike the pooled model, the Finnish model does pick up the 2000 peak, owing to the inclusion of the share market index in the model.

Estimation results: Finland

Variable	*Coefficient*	*Std. Error*	*z-Statistic*	*Prob.*
C	-2.878	0.486	-5.921	0.000
1/(IRL-INFL)	-0.063	0.016	-3.879	0.000
LNRHP-LNTRENDRHP	3.802	1.269	2.996	0.003
(D(IHQ)+D(IHQ(-1)))/2	3.955	1.269	3.116	0.002
DLOG(EQUITY)	9.267	2.891	3.205	0.001
Mean dependent var	0.066	S.D. dependent var		0.250
S.E. of regression	0.193	Akaike info criterion		0.311
Sum squared resid	4.308	Schwarz criterion		0.427
Log likelihood	-13.818	Hannan-Quinn criter.		0.358
Restr. log likelihood	-29.460	Avg. log likelihood		-0.114
LR statistic (4 df)	31.284	McFadden R-squared		0.531
Probability(LR stat)	2.68E-06			
Obs with Dep=0	113	Total obs		121
Obs with Dep=1	8			

Ireland

33. In Ireland the short-term interest rate interest rate turned out to be a much more powerful predictor than the long-term rate. Of the other explanatory variables included in the benchmark model only the moving average rate of real house price increase could be retained. The early-1990s peak is well-predicted.

Estimation results: Ireland

Variable	*Coefficient*	*Std. Error*	*z-Statistic*	*Prob.*
C	1.211	1.207	1.003	0.316
1/IRS	-31.996	14.090	-2.271	0.023
((RHP/RHP(-1)-1)+(RHP(-1)/RHP(-2)-1))/2	40.108	17.370	2.309	0.021
Mean dependent var	0.047	S.D. dependent var		0.213
S.E. of regression	0.179	Akaike info criterion		0.304
Sum squared resid	2.630	Schwarz criterion		0.390
Log likelihood	-9.909	Hannan-Quinn criter.		0.338
Restr. log likelihood	-16.130	Avg. log likelihood		-0.117
LR statistic (2 df)	12.441	McFadden R-squared		0.386
Probability(LR stat)	0.002			
Obs with Dep=0	81	Total obs		85
Obs with Dep=1	4			

Netherlands

34. The price gap dropped out of the equation. The interest rate could be retained, but only with a considerable distributed lag. An additional significant variable turned out to be the ratio of residential investment to GDP.

Estimation results: the Netherlands

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-6.717	5.026	-1.336	0.181
3/(IRL(-5)+IRL(-6)+IRL(-7))	-132.960	68.317	-1.946	0.052
((RHP/RHP(-1)-1)+(RHP(-1)/RHP(-2)-1))/2	54.644	21.405	2.553	0.011
IHQ	2.931	1.353	2.167	0.030
Mean dependent var	0.030	S.D. dependent var		0.171
S.E. of regression	0.127	Akaike info criterion		0.153
Sum squared resid	2.108	Schwarz criterion		0.240
Log likelihood	-6.269	Hannan-Quinn criter.		0.188
Restr. log likelihood	-17.986	Avg. log likelihood		-0.047
LR statistic (1 df)	23.434	McFadden R-squared		0.651
Probability(LR stat)	0.000			
Obs with Dep=0	130	Total obs		134
Obs with Dep=1	4			

New Zealand

35. For New Zealand the benchmark model performed reasonably well if complemented by two additional explanatory variables, the rate of change in the equity index lagged four quarters and the rate of inflation (although the nominal interest rate clearly outperformed the real interest rates). Unfortunately, this model fails to pick all peaks that have occurred in the past, and also signalled one in the early 2000s that did not happen (but which may still be in store).

Estimation results: New Zealand

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	2.168	1.054	2.058	0.040
1/IRL	-28.579	8.394	-3.405	0.001
LNRHP-LNTRENDRHP	4.701	2.331	2.017	0.044
((RHP/RHP(-1)-1)+(RHP(-1)/RHP(-2)-1))/2	31.895	10.896	2.927	0.003
EQUITY(-4)/EQUITY(-5)-1	-4.235	1.919146	-2.207	0.027
INFL	-0.101	0.05065	-1.997	0.046
Mean dependent var	0.118	S.D. dependent var		0.323
S.E. of regression	0.271	Akaike info criterion		0.546
Sum squared resid	9.527	Schwarz criterion		0.674
Log likelihood	-31.110	Hannan-Quinn criter.		0.598
Restr. log likelihood	-49.261	Avg. log likelihood		-0.220
LR statistic (5 df)	3.63E+01	McFadden R-squared		0.368
Probability(LR stat)	8.27E-07			
Obs with Dep=0	120	Total obs		136
Obs with Dep=1	16			

Norway

36. In Norway the benchmark model largely broke down. The real interest rate term could be retained, but only when entered with a long distributed lag. Residential investment, the unemployment rate, the inflation rate and the change in the ratio of residential investment in GDP are significant explanatory variables. There has been only one peak (in the mid-1980s) and this is well picked up by the model.

Estimation results: Norway

Variable	*Coefficient*	*Std. Error*	*z-Statistic*	*Prob.*
C	8.068	4.649	1.735	0.083
3/(IRL(-4)+IRL(-5)+IRL(-6))	-108.326	55.043	-1.968	0.049
D(IHQ)	11.687	4.972	2.351	0.019
INFL	-0.215	0.122	-1.768	0.077
Mean dependent var	0.029	S.D. dependent var		0.170
S.E. of regression	0.115	Akaike info criterion		0.146
Sum squared resid	1.741	Schwarz criterion		0.232
Log likelihood	-5.939	Hannan-Quinn criter.		0.181
Restr. log likelihood	-18.046	Avg. log likelihood		-0.044
LR statistic (4 df)	24.213	McFadden R-squared		0.671
Probability(LR stat)	0.000			
Obs with Dep=0	132	Total obs		136
Obs with Dep=1	4			

Spain

37. In Spain the benchmark model performed well. The predictive performance of the model is satisfactory: Spain has seen three housing peaks in the sample period and all three are predicted. The probability of a housing peak has been on an upward trend in recent quarters, but is still rather small.

Estimation results: Spain

Variable	*Coefficient*	*Std. Error*	*z-Statistic*	*Prob.*
C	-1.307	0.656	-1.992	0.046
1/IRL	-14.469	5.503	-2.629	0.009
((RHP/RHP(-1)-1)+(RHP(-1)/RHP(-2)-1))/2	23.268	9.849	2.363	0.018
LNRHP-LNTRENDRHP	8.259	2.666	3.097	0.002
Mean dependent var	0.090	S.D. dependent var		0.287
S.E. of regression	0.233	Akaike info criterion		0.387
Sum squared resid	7.087	Schwarz criterion		0.474
Log likelihood	-21.953	Hannan-Quinn criter.		0.423
Restr. log likelihood	-40.401	Avg. log likelihood		-0.164
LR statistic (3 df)	36.896	McFadden R-squared		0.457
Probability(LR stat)	0.000			
Obs with Dep=0	122	Total obs		134
Obs with Dep=1	12			

Sweden

38. In Sweden the benchmark model performed well, but was further improved by adding in an inflation term. The two peaks (early-1980s and early-1990s) are well captured.

Estimation results: Sweden

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	11.375	6.617	1.719	0.086
1/IRL	-176.337	81.625	-2.160	0.031
LNRHP-LNTRENDRHP	33.660	12.478	2.698	0.007
((RHP/RHP(-1)-1)+(RHP(-1)/RHP(-2)-1))/2	188.922	81.327	2.323	0.020
INFL	-0.352	0.169903	-2.075	0.038
Mean dependent var	0.057	S.D. dependent var		0.233
S.E. of regression	0.112	Akaike info criterion		0.150
Sum squared resid	1.690	Schwarz criterion		0.256
Log likelihood	-5.532	Hannan-Quinn criter.		0.193
Restr. log likelihood	-30.665	Avg. log likelihood		-0.040
LR statistic (4 df)	50.265	McFadden R-squared		0.820
Probability(LR stat)	3.18E-10			
Obs with Dep=0	132	Total obs		140
Obs with Dep=1	8			

Switzerland

39. Switzerland fitted the benchmark model very well, and no improvement could be realised by modifying it. The two peaks (early-1970s, late-1980s) are well captured.

Estimation results: Switzerland

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	4.417	3.443	1.283	0.200
1/IRL	-43.553	22.135	-1.968	0.049
LNRHP-LNTRENDRHP	8.362	3.303	2.532	0.011
((RHP/RHP(-1)-1)+(RHP(-1)/RHP(-2)-1))/2	99.813	35.206	2.835	0.005
Mean dependent var	0.057	S.D. dependent var		0.233
S.E. of regression	0.151	Akaike info criterion		0.190
Sum squared resid	3.099	Schwarz criterion		0.274
Log likelihood	-9.291	Hannan-Quinn criter.		0.224
Restr. log likelihood	-30.665	Avg. log likelihood		-0.066
LR statistic (3 df)	42.748	McFadden R-squared		0.697
Probability(LR stat)	0.000			
Obs with Dep=0	1.32	Total obs		140
Obs with Dep=1	8			

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