Housing Bubbles and Interest Rates*

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Preliminary draft

Abstract

In this paper we assess whether persistently too low interest rates can cause an overvaluation of real estate. To do this, we regress the deviation of real estate prices from their fundamental value (overvaluation) on the deviation of short term interest rates from the Taylor-implied interest rates. We additionally assess whether interest rates that have remained low for a longer period of time have a greater impact on house price overvaluation by calculating the number of consecutive periods that observed short term rates have been lower than those implied by the Taylor rule. Our results for 15 OECD countries indicate that there is a strong link between interest rate deviations and the overvaluation of real estate. This impact is especially strong when interest rates are too low, for too long. We argue that leaning against asset price fluctuations would not be necessary if central banks ensure that rates do not deviate too far from Taylor-implied rates.

1 Introduction

In the aftermath of the recent global financial crisis, central banks have been widely criticized for having kept interest rates too low for too long. As a consequence, an

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important strand of research has emerged focused on understanding whether rates that were too low spurred excessive risk taking in the banking sector leading to the buildup of the crisis (Maddaloni and Peydro, 2009; Altumbas et al., 2010; Cajueiro et al., 2010; Dubecq et al., 2010). Estimating deviations of short term rates from rates implied by some benchmark model, one set of authors have argued that a deviation from the Taylor rule was a primary cause in the build up of the financial crisis (see among others Taylor, 2010; Kahn, 2010; Nier and Merrouche, 2010). Others, however, have shown that direct linkages are weak at best and that financial market developments would have been only modestly different if monetary policy had followed a simple Taylor rule (Bernanke, 2010; Dokko et. al, 2009).

Another strand of literature has argued that property-price collapses have historically played an important role during episodes of financial instability (see among others Ahearne et al. 2005; Goodhart and Hofmann 2007). As a consequence, debate surrounding role that asset prices should play in monetary policy has been ripe. Some authors have called for central banks to react to movements in asset prices (Borio and Lowe 2002, Cecchetti et al. 2000) while others have shown that using monetary policy to lean against asset-price fluctuations may not be a sensible strategy (Assenmacher-Wesche and Gerlach, 2008).

In this paper, we add to the discussion by assessing the validity of accusations that policymakers created the current crisis by reacting insufficiently to growing inflation pressure or that they raised the likelihood of an asset price bubble by placing insufficient weight on credit and asset prices when setting interest rates. We do this by examining whether persistently too low interest rates can cause an overvaluation of real estate. Our methodology involves regressing the deviation of real estate prices from their fundamental value (overvaluation) on the deviation of short term interest rates from the Taylor-implied interest rates ("interest rates too low"). As an additional regressor, we define a dummy variable that captures the duration of a negative deviation of the observed interest rates ("for too long").

Our results for 15 OECD countries indicate that there is a strong link between interest rate deviations and the overvaluation of real estate. This impact is especially strong when interest rates are too low, for too long. Our findings have important policy implications with regards to monetary policy and asset prices. In particular, we argue that if interest rates are set at similar levels to those implied by the Taylor rule, real estate overvaluation can be reduced. We therefore show that leaning against asset price fluctuations would not be necessary if central banks ensure that rates do not deviate too far from Taylor-implied rates.

The rest of the paper is organized as follows. Section 2 describes our model for estimating real estate overvaluation. Section 3 estimates interest rate deviations from from Taylor-implied rates. Section 4 presents our estimations and discuss our findings. Section 5 briefly concludes.

2 Deviation of Real Estate Prices from their Fundamental Value

2.1 The Fundamental Real Estate Price Model

To calculate the fundamental value of real estate, we apply a similar approach as Hott and Monnin (2008): The fundamental value of a house (P_t) is given as the sum of the future discounted fundamental imputed rents (H_t). Fundamental imputed rents are defined as the market clearing price (i.e. rent) on a housing market.

To calculate the fundamental value of imputed rents, we assume that each household spends the autonomous amount $\bar{d}$ plus the fraction α of its income y_t per period on housing (Cobb-Douglas utility function). In period t the price for occupying a housing unit for one period (rent/ imputed rent) is H_t. Therefore, the demand for housing (d_t) is:

$$d_t = \alpha \frac{y_t}{H_t} + \bar{d}. \tag{1}$$

Further, we assume that in t there are N_t identical households. Hence, aggregated demand for housing (D_t) in period t is:

$$D_t = \alpha \frac{Y_t}{H_t} + (1-\alpha)\bar{d}N_t, \tag{2}$$

where $Y_t = y_t N_t$ is the aggregated income. Aggregated demand for housing, therefore, depends on the imputed rent, the number of households (or population) and the aggregated income (or GDP).

To calculate the supply of housing units in t (S_t) we assume that it is given as the depreciated supply in $t-1$ plus the construction of new housing units in $t-1$ (B_{t-1}). Backward iteration leads to the following supply function:

$$S_t = (1-\delta)S_{t-1} + B_{t-1} = (1-\delta)^t S_0 + \sum_{j=1}^{t} (1-\delta)^{j-1} B_{t-j}, \tag{3}$$

where δ is the depreciation rate of housing units and S_0 is the initial housing stock.

The market clearing condition is:

$$D_t = \alpha \frac{Y_t}{H_t} + \bar{d}N_t = S_t. \tag{4}$$

By rearranging this equation we get the fundamental value of rents:

$$H_t = \alpha \frac{Y_t}{S_t - \bar{d}N_t} = \alpha \frac{Y_t}{(1-\delta)^t S_0 + \sum_{j=1}^{t} (1-\delta)^{j-1} B_{t-j} - \bar{d}N_t}. \tag{5}$$

To derive the fundamental value of houses (P_t), we calculate the sum of the future discounted fundamental imputed rents (H_t). The discount factor is assumed to be the sum of the mortgage rate r_t in period t and the constant parameter ρ. This parameter ρ reflects a risk premium as well as maintenance costs (as a fraction of the house price).

$$P_t = E_t \left[\sum_{i=0}^{\infty} \frac{H_{t+i}}{\prod_{j=0}^{i} (1 + \rho + r_{t+j})} \right]. \tag{6}$$

By replacing H_t by the fundamental values of imputed rents from equation (5), we get the following fundamental house price equation:

$$P_t^* = E_t \left[\sum_{i=0}^{\infty} \frac{\alpha Y_{t+i}}{(S_{t+i} - \bar{d}N_t) \prod_{j=0}^{i} (1 + \rho + r_{t+j})} \right]. \tag{7}$$

Equation (7) implies that the fundamental value of houses is driven by present and future aggregated income, population, and mortgage rates and by past, present and future construction activities.

2.2 Calibration Method

2.2.1 Calibration of Fundamental Rents

In a first step to calibrate fundamental real estate prices we adjust the development of the fundamental imputed rents (H_t) to the development of the observed rents (M_t). While in the short run, actual rents can deviate from their fundamental values, in the long run, they do not develop completely independent. Hence, we choose parameter values that minimize the mean square difference (MSE) between actual and imputed rents. While doing this, we also have to make sure that the parameter values are not implausibly high or low.

According to equation (5), we need parameter values for α, $\bar{d}$, δ and S_0. In addition, since actual rents are expressed as an indicator, we need a conversion factor to compare their level with the righthand side of equation (5). Multiplying this conversion factor with the parameter α leads to the new parameter α_1. The allowed range of the four parameters is:

- $\alpha_1 > 0$ (preference parameter $1 \geq \alpha \geq 0$ multiplied with a positive conversion factor),
- $\bar{d} > 0$ (positive autonomous housing demand),
- $0.03 \geq \delta \geq 0$ (depreciation rate; based on assumptions in the literature[1]) and
- $S_0 \geq 0$ (positive initial housing stock).

Altogether we have to solve the following minimization problem:

[1] See, for example, Harding et al. (2006), McCarthy and Peach (2004), Pain and Westaway (1997) and Poterba (1992).

$$\min_{\alpha_1,\bar{d},\delta,S_0} \sum_{t=1}^{T} [m_t - h_t]^2 \tag{8}$$

where T is the end of our data sample, $m_t = \ln(M_t)$ and $h_t = \ln(H_t)$ and subject to: $\alpha_1 \geq 0$, $\bar{d} \geq 0$, $0 \leq \delta \leq 0.03$ and $S_0 \geq 0$.

2.2.2 Calibration of Fundamental Real Estate Prices

To calibrate fundamental house prices we use the calibrated series for H_t and assume that agents are rational and have perfect foresight.[2] We can, therefore, replace the expected future fundamentals in price equation (7) by their actual values. This implies that for $t \leq T$ and $i \leq t$:

$$E_{t-i}(H_t) = H_t \qquad \text{and}$$

$$E_{t-i}(m_t) = m_t.$$

For $t > T$, however, we do not have actual values of the fundamentals. For simplicity, we use a VAR model to forecast the values of the fundamentals after the end of our data sample ($t > T$). A problem is that H_t is not stationary. To deal with this problem, we look the derivation of the log imputed rents (h_t) from their trend (h_t^{trend}). We use a Hodrick-Prescott filter with a high λ to get a considerably stable trend.[3] Then we use the residuum $h_t^{res} = h_t - h_t^{trend}$ and the mortgage rate r_t for our VAR estimation. The number of lags included in the VAR is chosen by the Schwarz criterion, considering a maximum of four. In the next step we use the parameters of the VAR to calculate expected future interest rates and deviations of the imputed rents from their trend. We assume that the trend will grow constantly by $\bar{w} = h_{T+i+1}^{trend} - h_{T+i}^{trend}$, where $i \geq 0$. This constant is assumed to lie between the minimum (w^{min}) and the maximum (w^{max}) of the past growth of the trend. As a result we get forecasts for future imputed rents and mortgage rates.

[2]This assumption is equivalent to the 'ex post rational prices' in Shiller's (1981) work on stock prices.

[3]We use λ=400,000 with quarterly data.

To calibrate the fundamental property price, we still need a value for the sum of maintenance costs and risk premium ρ, the future growth of the trend ($\bar{w}$) and a conversion factor α_2 (rent index to property price index). The allowed range for the different parameter values is:

- $\alpha_2 > 0$ (positive conversion factor),
- $0.12 \geq \rho \geq -0.01$ (risk premium plus maintenance costs; based on assumptions in the literature) and
- $w^{max} \geq \bar{w} \geq w^{min}$ (country specific trend growth).

We chose parameter values that lead to the best fit between the log of fundamental ($p_t^* = \ln(P_t^*)$) and the log of actual prices ($p_t^a = \ln(P_t^a)$). Hence, we have to solve the following minimization problem:

$$\min_{\alpha_2,\rho,\bar{w}} \sum_{t=0}^{T} [p_t^a - p_t^*]^2 \tag{9}$$

subject to: $\alpha_2 > 0$, $0.12 \geq \rho \geq -0.01$ and $w^{max} \geq \bar{w} \geq w^{min}$.

2.3 Housing Data

We calibrate the model for 15 OECD countries: Australia (AU), Canada (CA), Finland (FI), France (FR), Germany (DE), Ireland (IE), Japan (JP), the Netherlands (NL), Norway (NO), Spain (ES), Sweden (SE), Switzerland (CH), the UK and the US.

According to equation 5), (7), (8) and (9), we need data on GDP (Y_t), population (N_t), construction (B_t), rents (M_t), mortgage rates (r_t) and real estate prices (P_t^a). Since we consider only real data, we also need CPI data.

The main data sources are the BIS, Datastream, IMF (IFS) and the OECD (MEI). For most series we have quarterly data from 1981 Q1 to 2010 Q3. The annual data on population data is transformed into quarterly data by linear interpolation and for some countries the time series are shorter.[4]

[4] The shortest time series is for IT: 1990 Q1 to 2010 Q1.

2.4 Calibration Results

Figure 1 shows the development of actual and fundamental real estate prices for the 15 OECD countries. As we can see, actual prices fluctuate much more than fundamental prices. According to Table 1, the standard deviation of actual real estate growth rates ($p_t^a - p_{t-4}^a$) is about three times higher than the standard deviation of fundamental real estate growth rates ($p_t^* - p_{t-4}^*$).

There are episodes with high deviations of actual real estate prices from their fundamental value (overvaluation). We can easily see the housing bubbles around 1990 and around 2007 in many countries. Given the definition of the fundamental real estate price, average overvaluation is (close to) zero. However, the standard deviation of the overvaluation varies between 9% (IT) and 37% (IE).

3 Interest Rates

3.1 Deviations from Taylor-rule implied rates

To address the issue of whether too low interest rates contribute to the build up of the real estate bubbles, we assess observed short term interest rates in 15 OECD countries relative to their Taylor-implied rates (Taylor, 1993). The Taylor rule is a benchmark policy tool that states that short-term interest rates should be a function of the following: (i) actual inflation relative to the targeted level; (ii) the deviation of economic activity from its full employment level and (iii) the level of short-term interest rates consistent with full employment. In general, interest rates should be higher when inflation is above target, $(\pi_t - \pi_t^*) > 0$, or when output is above its potential, $(y_t - y_t^*) > 0$. Taylor (1993) estimated the long-run real value of the federal funds rate to be about 2 percent. The equation for the Taylor rule accordingly shows that when inflation and output are equal to their targets, the policy rate should equal 2 plus the rate of inflation. Equivalently, when inflation and output equal their targets, the real value of the federal funds rate should equal 2 percent. The Taylor-implied rates are calculated in the following way:

$$i_t = \alpha_t + \pi_t + \beta_\pi(\pi_t - \pi^*) + \beta_y(y_t - y_t^*) \tag{10}$$

where α_t is the assumed equilibrium real interest rate, π_t denotes the inflation rate, π^* captures the desired rate of inflation, $y_t - y_t^*$ denotes the output gap: the difference between GDP (y_t) and its long-term potential non inflationary level (y_t^*). We set $\beta_\pi = \beta_y = 0.5$ and $\pi^* = 2\%$. The deviation of observed rates from the Taylor-implied rates can be calculated as:

$$(i_{jt} - i_{jt}^T) \tag{11}$$

for each country j in our sample.

3.2 Interest Rate Data

3.3 Summary Statistics

Table 2 presents the summary statistics of interest rate deviations for each country. The correlation matrix is presented in table 4. Fig 2 plots the evolution of the observed interest rates together with the Taylor-implied rates.

Of the 15 countries, six (Finland, Ireland, Italy, Spain, Switzerland and the US) have interest rates that have, on average, been too low over the sample period. In Finland, interest rates were too low for much of the 1980s and early 1990s. Since the introduction of the Euro in 1999, rates have remained consistently too low relative to the Taylor-implied rates. In Ireland, Italy, Spain, observed were too low in the early 1980s and similarly to Finland, have remained consistently too low since 1999. In Switzerland and the US, rates were generally too low in the late 1980s and early 1990s and again from the late 1990s. Pairwise correlations of interest rate deviations are, on average, positive and significant while correlations between observed rates and Taylor-implied rates range between 0.55 (Netherlands) and 0.89 (Italy).

4 Estimations

4.1 Too Low?

Our baseline regression for analyzing the relationship between real estate overvaluation and interest rate deviations from Taylor-implied rates can be written as:

$$(p^a_{jt} - p^*_{jt}) = \alpha_{jt} + \beta(i_{jt} - i^T_{jt}) + \epsilon_{jt}, \tag{12}$$

where $(p^a_t - p^*_t)_t$ captures real estate overvaluation and $(i_t - i^T_t)_t$ denotes interest rate deviations from Taylor-implied rates for country j at time t. We estimate equation (12) separately for each country, as well as within a system of equations using seemingly unrelated regressions (SUR).

Panel a of table 5 presents the results from estimating separate equations for each country. In most cases, interest rate deviations have a significant negative impact on real estate overvaluation. The finding provides evidence that low interest rates do contribute to real estate overvaluation, and subsequently, to the creation of housing bubbles. The impact is largest for Ireland where interest rate deviations explain up to 50% of real estate overvaluation. Here, a 1% deviation of interest rates from Taylor-implied rates results in a 6% overvaluation. In Switzerland, France and Canada, interest rate deviations of around 1% result in an overvaluation of around 2%. For the 15 countries in the sample, the average resulting overvaluation is around 4% following a deviation of around 1%.

SUR estimates assume that the error terms across the equations in a system are correlated. We test the independence of our equations using the Breusch-Pagan Lagrange Multiplier test (Zellner, 1962; Breusch and Pagan, 1980; and Greene, 1997) and find that the test rejects independence. We therefore re-estimate equation 12 using SUR. The results are presented in panel a of table 6. Our findings are qualitatively unchanged from those obtained using OLS. For those countries whose coefficients were not significant in the individual country equations. On average, interest rate deviations explain around 20% of real estate overvaluation in our sample.

4.2 Too low for too long?

To test whether interest rates that have remained low for a longer period of time have a greater impact on house price overvaluation, we create an additional variable that calculates the number of consecutive periods that observed short term rates have been lower than those implied by the Taylor rule. Here, a larger number corresponds with a longer period of loose policy rates. The dummy variable D_t is included in each regression as follows:

$$(p_t^a - p_t^*) = \alpha_t + \beta(i_t - i_t^T) + \gamma D_t + \epsilon_t. \tag{13}$$

Again we estimate using both OLS and SUR. The results of estimating equation 13 using SUR are presented in panel *b* of table 5. For each of the 15 countries in the sample, D_t is positive, and in most cases significant. This implies that the longer the rates deviate from the Taylor-implied rates, the greater the impact on real estate overvaluation. We find similar results using SUR estimations, presented in table 6 panel *b*. The *R-squared* increases on average from around 20% to 40% when we account for the duration of the rate deviation. For Ireland, interest rates and the length of the deviation from Taylor-implied rates together account for around 80% of real estate overvaluation. For Norway and Spain the corresponding amount is around 65% and around 45% for Switzerland, Finland and Sweden.

In a SUR system, parameters are estimated using the same number of observations for each equation. When equations are unbalanced, additional observations that are available for some equations, but not for all, are discarded, potentially resulting in a loss of efficiency. To test whether we lose efficiency from estimating with an unbalanced sample, we run a set of additional SUR regressions, omitting first Italy (81 observations) and then Ireland (91 observations). The results remain qualitatively unchanged when using more observations on a smaller sample of countries[5].

[5]Results using a smaller sample of countries are not presented here for brevity but are available from the authors on request.

5 Conclusions

In this paper, we add to the discussion on whether policymakers created the current crisis by reacting insufficiently to growing inflation pressure or that they raised the likelihood of an asset price bubble by placing insufficient weight on credit and asset prices when setting interest rates. We do this by examining whether persistently too low interest rates can cause an overvaluation of real estate. Our methodology involves regressing the deviation of real estate prices from their fundamental value (overvaluation) on the deviation of short term interest rates from the Taylor-implied interest rates ("interest rates too low"). As an additional regressor, we define a dummy variable that captures the duration of a negative deviation of the observed interest rates ("for too long").

Our results for 15 OECD countries indicate that there is a strong link between interest rate deviations and the overvaluation of real estate. This impact is especially strong when interest rates are too low, for too long. Our findings have important policy implications with regards to monetary policy and asset prices. In particular, we argue that if interest rates are set at similar levels to those implied by the Taylor rule, real estate overvaluation can be reduced. We therefore show that leaning against asset price fluctuations would not be necessary if central banks ensure that rates do not deviate too far from Taylor-implied rates.

References

Bernanke, Ben. S. (2010). 'Monetary Policy and the Housing Bubble', Speech at the Annual Meeting of the American Economic Association, Atlanta Georgia.

Breusch, Trevor and Adrian Pagan (1980). 'The LM Test and Its Application to Model Specification in Econometrics', Review of Economic Studies, 1980, 47, pp. 239-54.

Dokko, Jane, Brian Doyle, Michael T. Kiley, Jinill Kim, Shane Sherlund, Jae Sim, and Skander Van den Heuvel (2009). 'Monetary Policy and the Housing Bubble', Finance and Economics Discussion Series 2009-49. Washington: Board of Governors of the Federal System, December.

Greene, William H (1997). 'Econometric Analysis', 3 edition. rd Upper Saddle River, NJ: Prentice-Hall, 1997.

Harding, John P., Stuart S. Rosenthal and C.F. Sirmans (2007). 'Depreciation of Housing Capital, Maintenance, and House Price Inflation: Estimates from a Repeat Sales Model', *Journal of Urban Economics,* Vol. 61 (2), pp. 193-217.

Hott, Christian and Pierre Monnin (2008) Fundamental Real Estate Prices: An Empirical Estimation with International Data. *Journal of Real Estate Finance and Economics,* Vol. 36, No. 4, 427-450.

Kahn, George A. (2010). 'Taylor Rule Eeviations and Financial Imbalances', Economic Review, 2010, issue Q II, pages 63-99.

McCarthy, Jonathan and Richard W. Peach (2004). 'Are Home Prices the Next 'Bubble'?' *FRBNY Economic Policy Review,* December.

Nier, Erlend and Ouarda Merrouche (2010). 'What Caused the Global Financial Crisis - Evidence on the Drivers of Financial Imbalances 1999 - 2007?'No 10/265, IMF Working Papers from International Monetary Fund.

Pain, Nigel and Peter Westaway (1997). 'Modelling Structural Change in the UK Housing Market: A Comparison of Alternative House Price Models', *Economic Modelling,* Vol. 14, pp. 587-610.

Poterba, James M. (1992). 'Taxation and Housing: Old Questions, New Answers', *The American Economic Review,* Vol. 82 (2), pp. 237-242.

Taylor, John (2010). 'The Fed and the Crisis: A Reply to Ben Bernanke', The Wall Street Journal, p. A19.

Taylor, J. (2009). 'The Financial Crisis and the Policy Responses: An Empirical Analysis of What Went Wrong.' NBER Working Paper No. 14631.

Taylor, J. (2007). 'Housing and Monetary Policy,' in Housing, Housing Finance, and Monetary Policy Federal Reserve Bank of Kansas City.

Zellner, Arnold (1962). 'An efficient method of estimating seemingly unrelated regression equations and tests for aggregation bias.' Journal of the American Statistical Association 57: 348368.

Table 1: House Price Overvaluations

		p_t^a	-	p_{t-4}^a		p_t^*	-	p_{t-4}^*		p_t^a	-	p_t^*	
	observ.	mean	stdev	min	max	mean	stdev	min	max	mean	stdev	min	max
AU	97	0.04	0.07	-0.08	0.26	0.01	0.02	-0.03	0.06	0	0.24	-0.28	0.48
CA	119	0	0.05	-0.16	0.1	0	0.02	-0.04	0.05	0	0.13	-0.18	0.26
FI	131	0.02	0.1	-0.24	0.29	0.01	0.03	-0.07	0.09	0	0.23	-0.39	0.56
FR	122	0.03	0.08	-0.13	0.2	0.01	0.02	-0.05	0.04	0	0.27	-0.36	0.52
DE	113	0	0.02	-0.07	0.05	0.01	0.01	-0.02	0.04	0	0.15	-0.22	0.22
IE	91	0.04	0.09	-0.17	0.22	0.02	0.05	-0.07	0.1	0	0.37	-0.52	0.62
IT	81	0.02	0.04	-0.05	0.1	0.02	0.02	0	0.07	0	0.09	-0.16	0.14
JP	141	-0.01	0.04	-0.07	0.11	0.01	0.04	-0.11	0.07	0	0.28	-0.47	0.38
NL	103	0.04	0.05	-0.06	0.16	0.03	0.02	-0.01	0.08	0	0.25	-0.34	0.35
NO	120	0.04	0.08	-0.19	0.18	0	0.02	-0.06	0.04	0	0.32	-0.57	0.62
ES	95	0.04	0.07	-0.13	0.2	0	0.03	-0.07	0.06	0	0.33	-0.42	0.62
SE	99	0.04	0.07	-0.21	0.13	0.02	0.02	-0.03	0.07	0	0.18	-0.31	0.29
CH	143	0	0.05	-0.12	0.18	0.01	0.02	-0.03	0.04	0	0.17	-0.22	0.41
UK	97	0.02	0.1	-0.21	0.23	0.01	0.03	-0.05	0.08	0	0.25	-0.38	0.42
US	95	0	0.07	-0.23	0.12	0	0.02	-0.05	0.02	0	0.18	-0.23	0.41
average	110	0.02	0.07	-0.14	0.17	0.01	0.02	-0.05	0.06	0	0.23	-0.34	0.42

Table 2: Interest Rate Deviations

Variables	*Observations*	*Mean*	*Std dev*	*Min*	*Max*	*IR corr*
Australia	117	0.929	2.807	-7.438	7.715	0.82
Canada	117	0.769	2.548	-5.607	6.116	0.82
Finland	119	-0.875	3.399	-11.399	6.425	0.70
France	119	1.115	2.629	-7.814	8.510	0.86
Germany	119	0.848	1.879	-3.572	6.513	0.80
Ireland	118	-1.164	6.064	-18.946	9.454	0.56
Italy	119	-0.097	3.112	-10.025	8.048	0.89
Japan	98	0.331	1.810	-4.269	5.272	0.75
Netherlands	119	0.403	2.384	-5.513	7.033	0.55
Norway	117	1.159	3.860	-14.219	7.391	0.58
Spain	88	-0.759	3.229	-5.871	7.455	0.76
Sweden	113	0.727	3.160	-7.470	12.501	0.80
Switzerland	119	-1.238	1.804	-6.681	3.276	0.82
UK	117	0.344	2.495	-8.476	5.544	0.81
US	123	-0.631	2.802	-10.361	5.926	0.75

Note: IR corr refers to the correlation between the observed short term interest rate and the deviation from Taylor-implied rates.

Table 3: House Price Overvaluation: correlation matrix.

	Australia	Canada	Finland	France	Germany	Ireland	Italy	Japan	Netherlands	Norway	Spain	Sweden	Switzerland	UK	US
Australia	1														
Canada	0.59*	1													
Finland	0.40*	0.63*	1												
France	0.84*	0.64*	0.56*	1											
Germany	-0.72*	-0.06	-0.05	-0.47*	1										
Ireland	0.87*	0.35*	0.26*	0.65*	-0.87*	1									
Italy	0.54*	0.79*	0.50*	0.83*	0.08	0.35*	1								
Japan	-0.63*	0.25*	0.09	-0.43*	0.92*	-0.77*	0.10	1							
Netherlands	0.78*	0.11	0.05	0.47*	-0.94*	0.93*	0.07	-0.90*	1						
Norway	0.89*	0.33*	0.38*	0.75*	-0.87*	0.91*	0.29*	-0.77*	0.86*	1					
Spain	0.95*	0.62*	0.36*	0.89*	-0.68*	0.89*	0.65*	-0.60*	0.74*	0.88*	1				
Sweden	0.70*	0.89*	0.84*	0.88*	-0.27*	0.55*	0.68*	0.02	0.33*	0.64*	0.72*	1			
Switzerland	-0.31*	0.42*	0.54*	-0.03	0.75*	-0.52*	0.43*	0.79*	-0.72*	-0.48*	-0.31*	0.31*	1		
UK	0.77*	0.85*	0.78*	0.86*	-0.36*	0.68*	0.75*	-0.11	0.44*	0.68*	0.78*	0.89*	0.22*	1	
US	0.78*	0.45*	0.40*	0.68*	-0.67*	0.90*	0.50*	-0.54*	0.75*	0.77*	0.81*	0.58*	-0.26*	0.80*	1

Note: * denotes significance at the five percent level of significance.

Table 4: Interest Rate Deviation: correlation matrix.

	Australia	Canada	Finland	France	Germany	Ireland	Italy	Japan	Netherlands	Norway	Spain	Sweden	Switzerland	UK	US
Australia	1														
Canada	0.57*	1													
Finland	0.38*	0.45*	1												
France	0.41*	0.55*	0.38*	1											
Germany	0.01	0.32*	-0.22*	0.22*	1										
Ireland	0.56*	0.64*	0.64*	0.63*	0.20*	1									
Italy	0.55*	0.66*	0.69*	0.64*	0.27*	0.85*	1								
Japan	-0.02	0.38*	0.19	0.50*	0.43*	0.38*	0.42*	1							
Netherlands	0.37*	0.45*	0.19*	0.62*	0.38*	0.62*	0.53*	0.46*	1						
Norway	0.40*	0.50*	0.59*	0.36*	0.03	0.47*	0.67*	0.12	0.07	1					
Spain	0.60*	0.67*	0.25*	0.83*	0.34*	0.85*	0.81*	0.34*	0.69*	0.31*	1				
Sweden	0.18	0.41*	0.64*	0.35*	0.01	0.38*	0.54*	0.21*	0.19*	0.22*	0.23*	1			
Switzerland	0.39*	0.73*	0.45*	0.58*	0.18	0.55*	0.74*	0.35*	0.29*	0.34*	0.59*	0.65*	1		
UK	0.38*	0.51*	0.54*	0.60*	-0.01	0.55*	0.58*	0.50*	0.33*	0.47*	0.45*	0.35*	0.44*	1	
US	0.09	0.33*	-0.14	0.33*	0.24*	0.014	-0.01	0.35*	0.24*	-0.28*	0.56*	0.13	0.64*	0.36*	1

Note: * denotes significance at the five percent level of significance.

Table 5: Individual country regressions

	AU	CA	FI	FR	DE	IE	IT	JP	NL	NO	ES	SE	CH	UK	US
Panel I: estimating equation 12															
IR dev	-.030***	-.012***	-.031***	-.019**	-.009*	-.056***	-.004	-.067***	-.069***	-.006	-.062***	-.033***	-.019*	-.063***	-.054***
obs	95	117	118	119	113	91	81	98	103	117	95	97	119	95	95
R-sq	0.07	0.04	0.18	0.03	0.01	0.51	0.00	0.21	0.43	0.00	0.30	0.35	0.03	0.25	0.27
Panel II: estimating equation 13															
IR dev	-.041***	-.008**	-.023***	-.010	-.014***	-.028***	-.042***	-.042***	-.037***	-.003	-.051	-.021***	-.062***	-.031***	-.040***
dummy	.212**	.045**	.013**	.025	.002	.023***	.063***	.021**	.011***	.022**	.023***	.021***	.011***	.033***	.015***
obs	95	117	118	119	113	91	81	98	103	117	95	97	119	95	95
R-sq	0.08	0.05	0.22	0.15	0.13	0.80	0.42	0.23	0.23	0.65	0.03	0.42	0.42	0.35	0.31

Note: *, ** and *** denote significance at the ten, five and one percent level respectively. D_t captures the number of consecutive quarters that interest rates are below the Taylor-implied rates. A large dummy denotes interest rates that were too loose too long.

Table 6: Seeming unrelated regressions

	AU	CA	FI	FR	DE	IE	IT	JP	NL	NO	ES	SE	CH	UK	US
Panel I: estimating equation 12															
IR dev	-.016***	-.004***	-.044***	-.005***	-.006	-.043***	-.010***	-.005	-.064**	-.041***	-.033***	-.017***	-.013***	-.045***	-.026***
obs	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
R-sq	0.08	0.04	0.46	0.01	0.01	0.48	0.08	0.19	0.35	0.19	0.20	0.29	0.03	0.27	0.18
Panel II: estimating equation 13															
IR dev	-.031***	-.004*	-.048***	-.010***	-.012***	-.021***	-.017***	-.011	-.032***	-.067***	-.011***	-.012***	-.010***	-.013***	-.023***
dummy	.017***	.025**	.010**	.019***	.012***	.017***	.033***	.011***	.011***	.032***	.018***	.014***	.015***	.023***	.025***
obs	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
R-sq	0.11	0.09	0.47	0.19	0.14	0.81	0.42	0.36	0.25	0.65	0.64	0.42	0.47	0.37	0.33

Note: *, ** and *** denote significance at the ten, five and one percent level respectively. *Dummy*captures the number of consecutive quarters that interest rates are below the Taylor-implied rates. A large dummy denotes interest rates that were too loose too long.

Figure 1: *Real estate prices.*

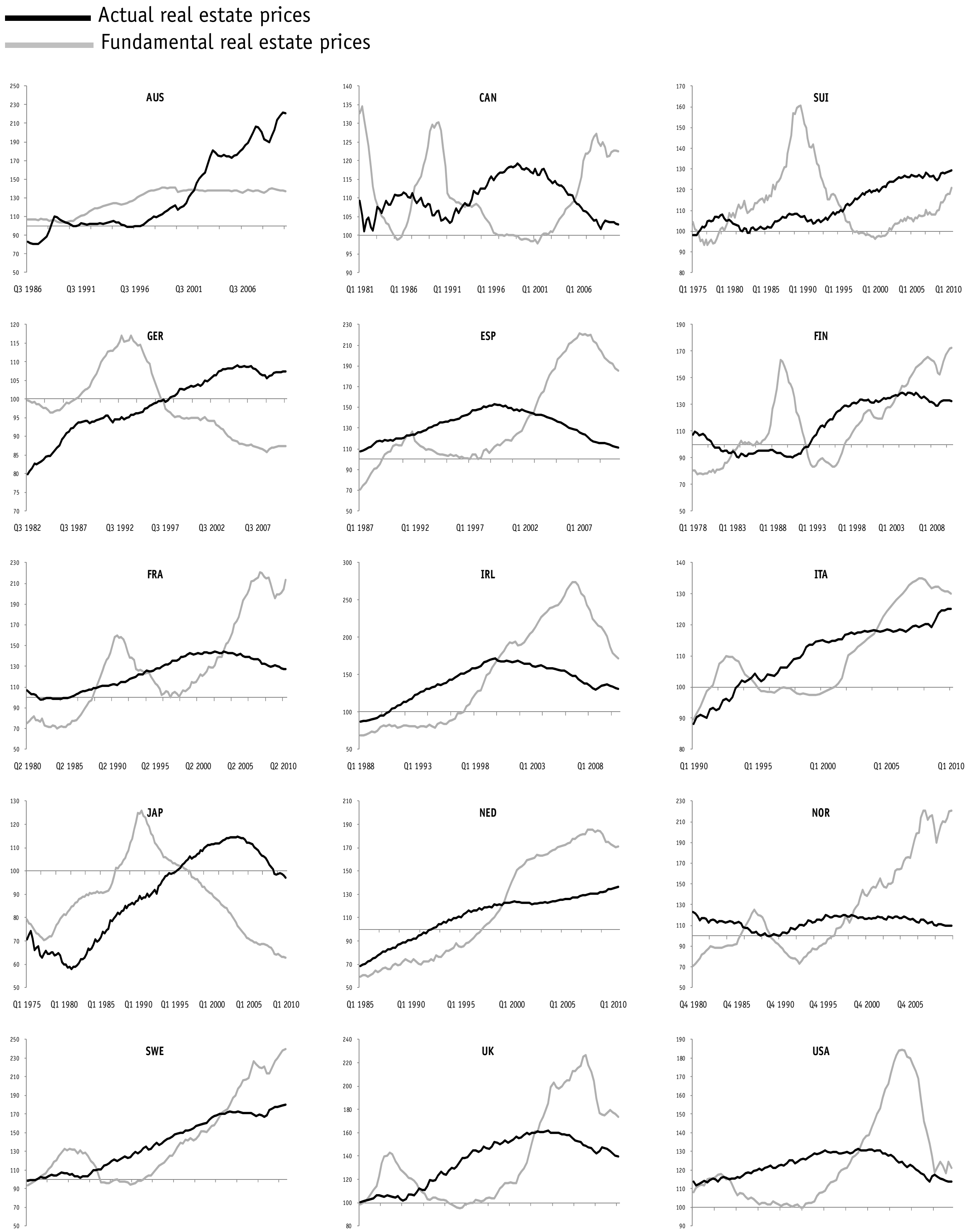

Figure 2: *Interest rates.*

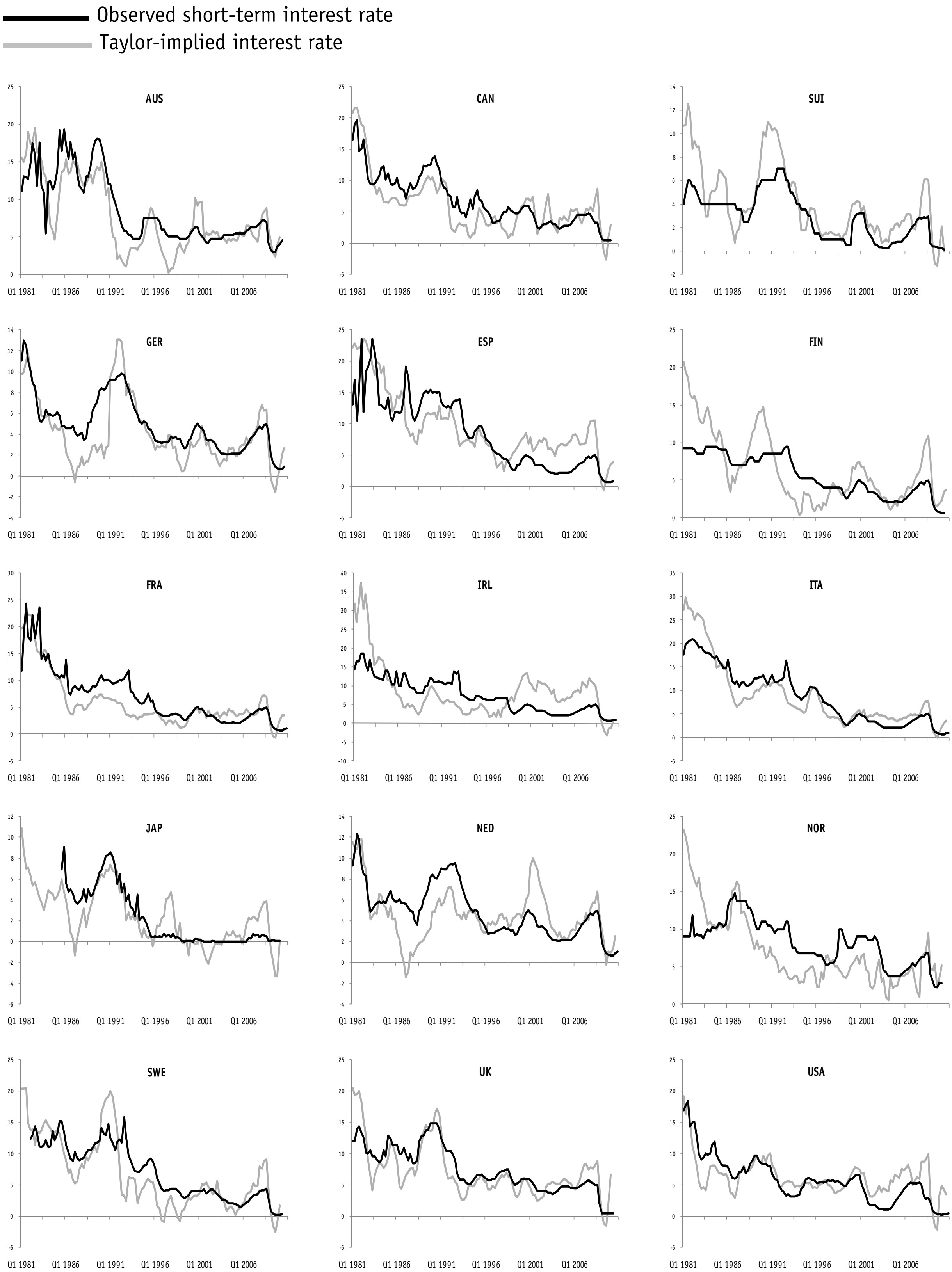

Figure 3: *Real estate price overvaluation and interest rate deviations.*