Explaining House Price Fluctuations

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Abstract

A comparison of fundamental house prices with actual prices indicates that house prices fluctuate more than fundamentally justified. This fact is very hard to explain with standard rational agent models. This paper develops a housing market model that allows to examine the price effects of various kinds of agents' expectations. In this framework I we show that the consideration of behavioural aspects like herding behaviour, speculation and momentum trading can help to explain actual house price fluctuations. Following the different approaches, agents overreact to fundamentals and are influenced by past price movements and returns.

Keywords: House Prices, Bubbles, Investor Behaviour.

JEL-Classifications: G11, G12, R21.

1 Introduction

Since Shiller (1981) and LeRoy and Porter (1981) we know that stock prices fluctuate much more than fundamentally justified. But what about house prices? In line with the phrase *as safe as houses*, it is (or at least it was) a widespread opinion that an investment in a house is a very safe decision. The recent burst of the housing bubbles in the US, the UK and many other countries has eroded this opinion, however.

Before the burst of the bubbles people saw many good reasons why house prices should be high. First of all many countries experienced a long episode of low interest rates and a relatively stable economic environment. Therefore, more people could afford more expensive

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houses and house prices increased. A problem was that many people started to believe that the benign conditions stay forever. In addition, the fact that house prices increased very strongly for some time made people believe that prices will also increase in the future. This led also to speculation and some households even started to buy second homes in order to profit from price increases. In order to climb up the property ladder, younger households felt pressure to buy a house before prices got too high. As a result of this focus on the momentum of prices, speculation and herding behaviour, house prices increased much more than the development of fundamentals would have justified. Since this development was not sustainable, house prices in many countries started to going down again. House prices fluctuated very strongly already in the past. The previous wave of house price bubbles and crashes happened a round 1990 in countries like Japan, Switzerland and the UK. This raises the question if there are fundamental reasons for these fluctuations or if other factors were driving forces.

To see if house prices fluctuate more than fundamentally justified, we calculate a fundamental house price and compare it to the actual price for six different countries: Switzerland (CH), Ireland (IRL), Japan (JAP), the Netherlands (NL), the UK and the US. While the house price development in each of these countries was different, they all experienced at least one housing cycle within the past 30 years. In CH, JAP and the UK a pronounced house price boom came to an end around 1990. Since then UK house prices revived again and increased very strongly between 1996 and 2007, CH house prices increased only moderately and real JAP house prices continued to decrease. While in the US and especially in IRL house prices increased very strongly between 1996 and 2006, in the NL the strongest increase was already between 1990 and 2000 (see Figure 2).

A very common way of assessing the fundamental value of houses is to look at the imputed rent of a house.[1] This imputed rent of a house reflects the costs that arise from owning a house for one period. In equilibrium these costs should be equal to the costs of renting a house for one period (actual rent). However, the problem is that actual rents are not necessarily fundamentally justified. Therefore, like Hott and Monnin (2008), to calculate the fundamental value of houses, in this paper we assume that imputed rents are equal to the

[1] Prominent examples are Poterba (1992) and Himmelberg et al. (2005).

fundamental value of rents.

The comparison of the resulting fundamental house prices with the corresponding actual prices indicates that house prices fluctuate more than fundamentally justified. One reason for this is that the fundamental model assumes that investors are rational and have perfect foresight. These are rather strong assumptions. Hence, to explain the divergent development, we develop several variations of the basic model with alternative assumptions about expectations. More precisely, we include the mechanism of existing models of investor behaviour, i.e. speculative bubbles, momentum trading and herding behaviour, into our house-price model and examine their influence on the development of prices.

The speculative bubble approach is based on Froot and Obstfeld's (1991) "intrinsic bubbles". Thereafter, the price of an asset is given by the sum of present value of future dividends (or in our case rents) and a bubble term. If the bubble term depends on the development of fundamentals, this leads to an overreaction to these fundamentals.

The momentum approach is based on Hong and Stein's (1999) "newswatchers" and "momentum traders". Thereafter, expectations are partly influenced by fundamentals and partly influenced by the momentum of the price development. This leads to higher amplitudes and a higher persistence of price fluctuations.

Finally, the herding behaviour approach is based on Lux (1995). He develops a model where there is a positive feedback effect between the development of market prices and investors' sentiment. Increasing prices enhance the sentiment of investors. The more optimistic investors push the price even higher and the sentiment increases further. The opposite is the case when the price declines. These effects amplifies house price fluctuations.

The calibration of the different model variations indicates that these alternative assumptions on investor behaviour can help to explain the fluctuations of actual house prices. This examination of behavioural aspects in a house price model is the main innovation of this paper.[2]

In the next section we present the basic model of fundamental house prices. We also describe the calibration of the model and present the results. In section 3 we examine the

[2]Brunnermeier and Julliard (2008) also aim to explain the difference between rational (or fundamental) house prices and actual house prices. The authors concentrate their analysis on the effects of inflation and their results suggests that money illusion might affect the actual house price development. This finding does not contradict our findings, instead it can be seen as an additional source of house price fluctuations.

effects of different forms of expectations regarding the development of house prices. Section 4 offers some concluding remarks.

2 The Fundamental Value of Houses

2.1 The Model

In this section we develop a model that enables me to calculate the fundamental value of houses. A feature of the housing market is that houses serve as an investment as well as a good that serves utility.[3] Hence, the following model combines the asset and the market view of house prices. We start with the asset view, where the house price is defined as the present value of future imputed rents. The fundamental value of (imputed) rents will then be calculated over a market equilibrium. By replacing the imputed rent in the present value equation by its fundamental value, we get an equation for the fundamental value of houses.

The Asset View: The starting point of the calculation of fundamental house prices is the imputed rent. Imputed rents are defined as the sum of the costs that arise from owning a house per period. As a fraction of the house price these costs are also known as the user costs of housing.

The literature is proposing different factors to capturing the imputed rent of a house. Poterba (1984 and 1992), McCarthy and Peach (2004) and Himmelberg et al. (2005), for example, use very similar factors to define imputed rents: On the one hand, the owner of a house has to pay the mortgage rate (or the opportunity costs in the form of missed interest rate payments), the house is subject to depreciation and the owner has to pay for maintenance, repairs and property taxes. Furthermore, he or she bears the risk of a change in house prices or unforeseeable investment needs which has to be compensated by a risk premium. On the other hand, the owner of a house can profit from potential capital gains.

Like Hott and Monnin (2008), we combine the above mentioned factors into three main factors to calculate the user costs of a house: The first factor is the mortgage rate m_t in period t. The second factor is the sum of maintenance costs (as a fraction of the house price) and a risk premium. This factor is reflected by the constant parameter ρ.

[3] Correspondingly Holly and Jones (1997, p 553) write: "The determination of house prices can be considered in two complementary ways: as the outcome of a market for the services of the housing stock and as an asset."

The third factor is the expected capital gain. Dougherty and Van Order (1982), for example, assume that real house prices are constant and Himmelberg et al. (2005) use the interest rate spread and the average real growth rate of house prices to predict their future nominal growth rate. While these assumptions might be adequate for the purpose of their studies, they are not suitable for the calculation of a fundamental house price. We instead will calculate the expected capital gain via the expected house price in the next period $[E_t(P_{t+1})]$ and a constant physical depreciation (δ) of houses. Hence, as a fraction of the current house price the expected capital gain is $[(1-\delta)E_t(P_{t+1}) - P_t]/P_t$.

To calculate the imputed rent H_t of a house, we multiply the resulting user costs with the price of a house and get:

$$H_t = (m_t + \rho + 1)\, P_t - (1-\delta)E_t(P_{t+1}). \tag{1}$$

Rearranging equation (1) yields the following house price equation:

$$P_t = \frac{H_t + (1-\delta)E_t(P_{t+1})}{R_t}, \tag{2}$$

where $R_t = 1 + \rho + m_t$. To get the expected house price, we assume that agents are rational. Forward iteration then implies that:

$$P_t = E_t\left[\frac{H_t}{R_t} + \frac{(1-\delta)H_{t+1}}{R_t R_{t+1}} + \frac{(1-\delta)^2 H_{t+2}}{R_t R_{t+1} R_{t+2}} ...\right] \tag{3}$$

or

$$P_t = E_t\left[\sum_{i=0}^{\infty} \frac{(1-\delta)^i H_{t+i}}{\prod_{j=0}^{i} R_{t+j}}\right]. \tag{4}$$

This result is very similar to Shillers (1981) "simple efficient markets model" whereafter the price of a stock should be equal to the sum of all future discounted dividends.[4] Following equation (4), the fundamental price of a house is driven by present and future imputed rents and mortgage rates.

It is very common to assume that imputed rents are equivalent to the corresponding actual rents. This assumption is equivalent to assuming that there is a no-arbitrage condition between buying and renting a house. However, we do not know if rents are fundamentally

[4] Shiller (1981) uses a constant discount factor and an observable real dividend.

justified. The rent market might be, for example, influenced by imperfect information or by government intervention. Hence, to calculate the fundamental value of houses, we need to calculate the fundamental value of rents as well.

The Market View: To calculate the fundamental value of rents, we assume that they are the outcome of a market for housing. In other words, H_t leads to a demand for housing which is equal to the supply of housing.

We start with the demand side of the market for housing. Note that this demand is not equal to the demand for houses. It is only the demand for the right to occupy a house for one period (by renting or by buying it). This demand is derived from agents' utility function and their budget restriction. We assume that in period t there are N_t identical individuals which derive their utility from consumption c_t and the occupation of housing units d_t. Their utility U_t is assumed to be:[5]

$$U_t = \left(d_t - \bar{d}\right)^{\alpha} c_t^{1-\alpha}, \tag{5}$$

where α reflects the strength of the preferences for housing compared to the preferences for consumption. The parameter $\bar{d}$ is the minimum housing demand of the agent under the condition that he or she can afford it.

To derive the budget restriction of agents we assume that the income of each agent is y_t. The price of the consumption good is normalized to one and the period cost for the right to occupy one housing unit (rent or imputed rent) is H_t. For simplification we further assume that agents do not have the possibility to save money and to transfer utility into the future.[6] Therefore, agents spend their entire income on consumption and housing:

$$y_t = H_t d_t + c_t. \tag{6}$$

The utility maximizing demand for housing is:

[5]Pain and Westaway (1997) and Schwab (1982) also assume that the utility depends on consumption and housing. While they assume that the consumption good and the housing units are substitutes, we assume that they are complementary goods.

[6]Usually, the consideration of savings and, thereby, the intertemporal distribution of wealth is necessary and important to link today's market equilibrium to the future development of fundamentals. In our model, however, this link is already given by the discounted future imputed rents following the asset view.

$$d_t = \alpha \frac{y_t}{H_t} + (1-\alpha)\bar{d}. \tag{7}$$

Hence, with a positive minimum housing demand $\bar{d}$, the resulting optimal housing expenditures $(d_t H_t)$ of an agent does increase less than proportional with his or her income - which is a realistic result. Since all agents are assumed to be equal, we can calculate the aggregate demand for housing (D_t) by multiplying individual demand with the number of agents (N_t) in period t:

$$D_t = \alpha \frac{Y_t}{H_t} + (1-\alpha)\bar{d}N_t, \tag{8}$$

where $Y_t = y_t N_t$ is aggregate income. Aggregated demand for housing, therefore, depends on the imputed rent, the number of agents (or population) and aggregate income (or GDP). This result is consistent with the literature. Case and Shiller (2003), for example, consider personal income per capita, population, employment and the unemployment rate and Collyns and Sendhadji (2002) name the real GDP as a measure for the aggregate level of income and population.

To calculate the equilibrium imputed rent, we also need to consider fluctuations in the supply of housing units.[7] The supply of housing units (S_t) is positively influenced by the construction of new housing units (B_t) and negatively influenced by the depreciation (δ) of existing housing units. We assume that construction takes one period and leads to B_t new housing units in $t+1$. Backward iteration shows that today's housing supply is determined by all former construction activities, the depreciation rate and the initial housing stock S_0:

$$S_t = (1-\delta)S_{t-1} + B_{t-1} = (1-\delta)^t S_0 + \sum_{j=1}^{t} (1-\delta)^{j-1} B_{t-j}. \tag{9}$$

The housing market is in equilibrium if demand is equal to supply:

$$D_t = \alpha \frac{Y_t}{H_t} + (1-\alpha)\bar{d}N_t = S_t. \tag{10}$$

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

[7] Glaeser et al. (2005, p 2) and McCarthy and Peach (2004, p 9) also point out that the supply side has to be considered.

$$H_t = \alpha \frac{Y_t}{S_t - (1-\alpha)\bar{d}N_t} = \alpha \frac{Y_t}{(1-\delta)^t S_0 + \sum_{j=1}^{t}(1-\delta)^{j-1}B_{t-j} - (1-\alpha)\bar{d}N_t}. \qquad (11)$$

The Fundamental House Price Equation: By replacing imputed rents in price equation (4) by their fundamental values, we get the following fundamental house price equation:

$$P_t^* = E_t \left[\sum_{i=0}^{\infty} \frac{(1-\delta)^i \alpha Y_{t+i}}{S_{t+i} \prod_{j=0}^{i} R_{t+j} - (1-\alpha)\bar{d}N_t} \right]. \qquad (12)$$

Equation (12) 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 Data

Before calibrating this fundamental house price for different countries, we will briefly present the required data. We will examine the housing markets in Switzerland (CH), Ireland (IRL), Japan (JAP), the Netherlands (NL), the UK and the US. Each of these housing markets experienced at least one house price cycle within the past 30 years. However, the house price development was different in each of these countries. This fact provides a good test for the model and the overall approach.

According to equation (11) and (12) we need data on GDP (Y_t), construction (B_t), population (N_t) and mortgage rates (m_t) for all six countries. Calibration also requires data on actual rents (M_t) and actual house prices (P_t^a). To transform the nominal series into real ones, we need data on the development of the CPI (CPI_t). With the exception of population (N_t) the frequency of the data series is quarterly. The series on population data is transformed into quarterly data by linear interpolation. The time horizon of the different series varies, but they all capture at least one property-price cycle. The main sources are the BIS, the IMF, and the OECD. For more details on the data, see Appendix A.

2.3 Calibration

To calibrate fundamental house prices we assume that agents are rational and have perfect foresight.[8] We can, therefore, replace the expected future fundamentals in price equation

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

(12) by their actual values. There are two problems left: (i) we do not know how the fundamentals evolve after the end of the data sample and (ii) we have to find adequate values for the different parameters.

The Future Values of Fundamentals: Following the price equation (12), the calculation of the fundamental house price requires all future fundamentals up to infinity. In lack of such data, we have to make assumptions about the development of fundamentals after the end of the data sample (period T).

For simplicity we assume that H_t evolves at the constant growth rate w and that mortgage rates stay constant from period $T+1$ on:

$$\begin{aligned} H_{T+i+1} &= (1+w)H_{T+i} \quad \text{and} \\ m_{T+i+1} &= \bar{m}, \end{aligned}$$

where $i \geq 0$. The choice of the parameters w and $\bar{m}$ has a substantial impact on fundamental house prices at the end of the sample and also on their recent development. Though, its influence on the earlier prices and past price fluctuations is rather small. Hence, for the purpose of this study, our rough estimates of the parameter values are sufficient. If, on the other hand, someone wants to judge the present price level, he or she has to be much more careful. Another possibility would have been to make an assumption about the future price directly. Though, our approach enables me to check if the future price increase is implausible high or low.

The price equation (12) for $T+1$ can now be transformed into:

$$P^*_{T+1} = \alpha \frac{(1+w)H_T}{\rho + \bar{m} + \delta - w + \delta w}. \tag{13}$$

To calculate this future fundamental house price, we need values for the two additional parameters: w and $\bar{m}$.

We now turn to finding adequate values for the different parameters: the preference (marginal rate of substitution) α, the minimum housing demand $\bar{d}$, the depreciation rate δ, the sum of maintenance costs and the risk premium ρ and, to calculating the fundamental house price in $T+1$, the growth rate of the imputed rent w and the average mortgage rate $\bar{m}$. In addition to this, note that some of the data series are expressed as an index, meaning that the levels of the different series are not directly comparable. Hence, to compare the right sides of equation (11), (12) or (13) with their left sides, we need suitable conversion factors.

The Calibration of Fundamental Rents: In a first step to calculate fundamental house prices we use the fact that imputed rents (H_t) are equal to the fundamental values 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 will choose parameter values (α, $\bar{d}$, δ and S_0) that will minimise 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.

The first parameter is α. Equation (11) states that α does not have an effect on the growth rates of H_t, but only on its level. As already mentioned, we also need a conversion factor to adjust the level of rents. If we multiply α with a conversion factor we get the new parameter α_1. It is obvious to assume that this parameter should be positive, but there is no upper bound to this parameter. This is true for all six countries in our sample.

The second parameter is the constant minimum housing demand $\bar{d}$. In the rent equation (11) this parameter is multiplied with the constant $(1-\alpha)$. We define a new parameter $\hat{d} = (1-\alpha)\bar{d}$ and assume the lower bound for this new parameter is zero and that there is no upper bound. This applies to all six countries in the sample.

The third parameter is the depreciation rate δ. Harding et al. (2006) estimate that, net of maintenance, the yearly depreciation rate is 1.9 percent. McCarthy and Peach (2004) assume that the depreciation rate plus repairs is 2.5 percent per year, Pain and Westaway (1997) assume a depreciation rate of 0.9 percent and Poterba (1992) assumes two percent. We do not assume a particular depreciation rate but allow a (plausible) range. We assume for all six countries identical lower and upper bounds for the parameter δ: They are zero and four percent, respectively.

The forth parameter is the initial housing stock S_0. The only restriction to this parameter is that it can not be negative. Therefore, we assume that the lower bound of S_0 is zero and that there is no upper bound. This applies to all six countries.

Altogether we have to solve the following minimisation problem:

$$\min_{\alpha_1,\hat{d},\delta,S_0} \sum_{t=0}^{T} \left[\alpha_1 \frac{Y_t}{(1-\delta)^t S_0 + \sum_{i=1}^{t}(1-\delta)^{i-1} B_{t-i} - \hat{d} N_t} - M_t \right]^2 \tag{14}$$

subject to: $\alpha_1 \geq 0$, $\hat{d} \geq$, $0 \leq \delta \leq 0.04$ and $S_0 \geq 0$.

To solve this minimisation problem, we use the "solver" from Microsoft-EXEL. The results of the calibration are displayed in Figure 1. For comparison actual rents are displayed as well. As we can see, the development of rents is quite smooth compared to the development of house prices (see Figure 2). We can also see that the fit between actual and fundamental rents is quite good. According to Table 1 the mean deviation of the fundamental rents form the actual values varies between 1.4% (US) and 11.9% (IRL).

Table 1 also shows the different parameter values. Thereafter, in five out of the six countries δ is very small. On the other hand, in these countries α_1 and S_0 are relatively high. The effect of this combination of parameter values is that construction and, therefore, the change in supply has only a small effect on the development of rents. However, the overall effect of the parameter δ on the fundamental rent is rather low. If, for example, the parameter δ would be 4% in these five countries, the mean deviation of the fundamental rents from the actual rents would increase by only between 0.3 (UK) and 3.8 (CH) percent points.

Another noticeable point with regard to the parameter values is that for the UK $\hat{d}$ is zero and therefore at its lower bound. Following equation (14) this implies that the development of the population N_t has no direct effect on rents (although it still has an indirect effect via aggregated income $Y_t = y_t N_t$). However, the fundamental rent is not very sensitive to changes in the parameter $\hat{d}$. Even if it would be 30 (highest value for the other countries), the mean deviation of the fundamental rents from the actual rents would increase by only 0.15 percent points.

[Insert Figure 1 about here]

[Insert Table 1 about here]

Calibration of Fundamental House Prices: In the second step of the calibration we adjust the fundamental house prices (P_t^*) to the development of actual house prices (P_t^a). To calculate fundamental house prices we use the calibrated series for H_t. The remaining parameters are the sum of maintenance costs and risk premium ρ, the future growth rate of imputed rents w, the future mortgage rate $\bar{m}$ and a conversion factor α_2.

To get appropriate limits for the parameter ρ we add up the limits of maintenance costs and risk premium. Harding et al. (2006) estimate that maintenance costs are between 0.5 and one percent. Poterba (1992), on the other hand, assumes that maintenance costs are about two percent. We assume that the lower and upper bounds of the maintenance costs are zero and three percent, respectively.

There are also different assumptions with regard to the risk premium: Himmelberg et al. (2005) assume that the risk premium is two percent, Pain and Westaway (1997) assume that it is between two and eight percent and Poterba (1992) assumes four percent. Sinai and Souleles (2005), on the other hand, point out that there is also a risk of rent changes. If someone buys a house he or she bears the risk of changes in the house price but he or she avoids the risk of a change of the rent. Therefore, the risk premium for owning a house can be positive or negative. Since the risk of house price changes only materializes if the house is sold but rent changes can materialize in each period the overall risk premium depends on the time someone wants to keep a certain house. In this paper we assume that the risk premium is between -1 and 9 percent. Hence, altogether, the lower and upper bound for the parameter ρ in each country is -1 and 12 percent, respectively.

As already mentioned, the choice of the parameter w and $\bar{m}$ has mainly an effect on the development of the resulting fundamental house prices at the end of the sample and barely influences past price fluctuations. Nevertheless, we consider realistic boundaries for these parameters, by looking at country specific developments. To find appropriate values for the future growth rate of imputed rents (w), we look at historical growth rates in the different countries. First, we compute the average growth rates of the imputed rents by considering the complete sample, the previous twenty and the previous ten years. Then, in order to set the upper bound for the parameter, We round up the maximum of the three growth rates to the next 0.5 percent and add 0.5 percent. For the lower bound we round down the minimum of the three growth rates to the next 0.5 percent and subtract 0.5 percent. Thereafter, the lower and upper bounds for CH are 0 and 2 percent, for IRL they are -3 and 1.5 percent, for JAP -2 and 1.5 percent, for NL 1 and 3 percent, for the UK 0.5 and 2.5 percent and for the US -0.5 and 1.5 percent.

For the parameter $\bar{m}$ we look at historical real mortgage rates in the different countries. Corresponding to the choice of the boundaries for the growth rates of the imputed rents we compute the average real mortgage rate of the complete sample, the previous twenty and the previous ten years. Then, to set the upper bound for the parameter, we round up the maximum of the three mortgage rates to the next 0.5 percent and add 0.5 percent. For the lower bound we round down the minimum of the three mortgage rates to the next 0.5 percent and subtract 0.5 percent. Thereafter, the lower and upper bounds for CH are 1.5 and 4 percent, for IRL they are 0.5 and 4.5 percent, for JAP 1.5 and 3.5 percent, for NL 2 and 5 percent, for the UK 2 and 5 percent and for the US 3 and 5.5 percent.

For the conversion factor α_2 we only assume that it is positive. As a result, we have to solve the following minimisation problem:

$$\min_{\alpha_2,\rho,w,\bar{m}} \sum_{t=0}^{T} \left[\frac{\alpha_2 H_t + \delta P^*_{t+1}}{1+\rho+m_t} - P^a_t \right]^2 \tag{15}$$

subject to: $\alpha_2 > 0$, $-0.01 < \rho < 0.12$ and the corresponding upper and lower bounds of w and $\bar{m}$. The house price in period $T+1$ (P^*_{T+1}) is calculated according to equation (13).

The results of the calibration are presented in Figure 2. For comparison, actual house prices are displayed as well. As we can see, actual house prices are much more volatile than fundamental prices. On average the variance of the growth rates of actual prices $Var(\Delta P^a_t)$ is almost six times higher than the variance of the growth rates of fundamental house prices $Var(\Delta P^*_t)$. However, according to Table 2 this proportion differs between countries. In Japan, the Netherland and Switzerland it is very high. In Ireland and the US, on the other hand, the proportion is rather low. A reason for the low proportion in the US might be that its housing market is very large and regional excess volatility might be evened out. Another reason might be that we look at the rather smooth development of the OFHEO Index as a reference for US house prices. The Variance of the Case Shiller National Home Price Index, for example, is about twice as high. In Ireland the proportion is low because the variance of the fundamental house price is high as well. Until the mid 1980s Ireland experienced a rather negative development. However, between the end of the 1990s and the end of the sample, the country grew with an enormous pace. This change is reflected in the high variance of the growth rates of actual as well as fundamental house prices.

[Insert Figure 2 about here]

On average fundamental house prices deviate by about 17% from actual house prices. Following Table 2 the lowest average price deviation is in the US (8%) meaning that actual house prices are reflected by the fundamental model quite well. The highest average deviation is in IRL (32%). Here the fit between actual and fundamental house prices is rather poor.

In each of the six countries under consideration, there are phases of substantial under- and overvaluations. We can easily detect price bubbles around 1990 in CH (45% higher than the fundamental house price), JAP (30%) and the UK (55%). These overvaluations are also indicated by other studies. Ayuso and Restoy (2006), for example, identify the UK bubble by comparing the development of the actual price-to-rent ratio with its equilibrium path. Muellbauer and Murphy (1997) also examine the UK housing boom around 1990 and conclude that the housing market is far from efficient. Stone and Ziemba (1996, p 163) argue that it appears likely that the Japanese housing boom in the late 1980s "... went somewhat beyond what could be justified based on fundamental factors."

When we look at Figure 2, in general the peaks seem to be more pronounced than the troughs. This is also indicated by the maximum and minimum relative price difference between actual and fundamental house prices as shown in Table 2. Thereafter, on average the maximum price deviation at the peaks is about 70% higher than the maximum price deviation at the troughs. This is consistent with the conventional view that bubbles are a positive deviation of the price from its fundamental value. A reason for this might be that, especially in housing markets, short selling is much more difficult than pushing a price up by extensively buying an asset. Diba and Grossman (1988, p 747) even argue that there are no negative rational bubbles and write:

"The fact that rational bubbles have explosive conditional expectations implies that a negative rational-bubbles component cannot exist, because, given free disposal, stock holders cannot rationally expect a stock price to decrease without bound and, hence, to become negative at a finite future date."

[Insert Table 2 about here]

Table 3 shows the values of the different parameters. There are two noticeable points with regard to these parameter values. Firstly, for JAP and the US the parameter ρ (sum of maintenance costs and risk premium) is at its upper bound of 12%. A reason for this might be that real interest rates were very volatile (in each of the six countries), especially in the 1970s. A high ρ lowers the price effect of changing mortgage rates. This in turn implies that the influence mortgage rates on house prices in JAP and the US was rather low. However, the effect of the parameter ρ on the price development is rather small. Even with a ρ of -1 (lower bound), the average deviation of the house price from its fundamental value in JAP and the US would increase by only 3 and 2 percent points, respectively.

The second noticeable point with regard to the parameter values is that all values for future mortgage rates $\bar{m}$ and for future growth rates w are either at their upper or their lower bounds. As already mentioned, these parameters have mainly an effect on the recent development of fundamental house prices. A high w and a low $\bar{m}$ indicate that prices are currently rather high and a low w and a high $\bar{m}$ indicate that prices are currently rather low. For IRL, the NL, the UK and the US the parameter w is at its upper bound and the parameter $\bar{m}$ is at its lower bound. Despite these parameter values actual house prices in these countries are noticeably higher than their fundamental values at the end of the data sample. This indicates that prices in these countries were rather high at the end of the data sample in late 2007. The opposite is the case in CH and JAP. These results are consistent with the findings of other studies. Ayuso and Restoy (2006), for example, show that price-to-rent ratios recently exceeded their fundamental values in the UK and the US. Also Shiller (2007, p 4) argues that the recent "... dramatic price increase is hard to explain, since economic fundamentals do not match up with the price increases."

[Insert Table 3 about here]

3 Why Do House Prices Fluctuate More Than Fundamentally Justified?

The result that actual asset prices fluctuate more than fundamentally justified is not a new finding. Starting with Shiller (1981) and LeRoy and Porter (1981) many studies have examined the relationship between actual and fundamental prices in stock markets.[9] These studies show that actual prices cannot be fully explained by the fundamental (present value) model. Shiller (1981, p 434) argues:

> "The failure of the efficient markets model is thus so dramatic that it would seem impossible to attribute the failure to such things as data errors, price index problems, or changes in tax laws."

Shiller attributes the differences to irrational behaviour of the investors. In our basic model we not only assume that people are rational but also that they have perfect foresight,[10] and thereby make very strong assumptions about investors' forecasting abilities. To describe real world developments, these assumptions have to be relaxed. Coakley and Fuertes (2006), however, point out that prices reflect fundamentals in the long run.[11] This is also the case in our model. Therefore, the development of the price cannot be completely independent from fundamentals.

Theoretical literature is offering different possible explanations for excess price fluctuations or the occurrence of price bubbles. Very popular ideas are: speculative bubbles, momentum trading and herding behaviour. We will apply these three explanations to our basic house-price model by transforming existing and established models. But before that, we will look at a rather simple form of adaptive expectations: *constant user costs*. The main purpose of this additional approach is to lay the ground for the introduction of the three main model variations. However, already the *constant user costs* approach provides some interesting results. We will calibrate all four model variations for the six countries under

[9]Coakley and Fuertes (2006), for example, analyze the time-series dynamics of post 1870 S&P valuation ratios. Their results indicate that prices can deviate substantial from their fundamental value in the short run. Zhong et al. (2003) examine the behaviour of post-World War II US-stock prices. They conclude that the present value model is unable to explain actual market behaviour.

[10]With his ex-post rationality, Shiller (1981) implicitly also assumes that investors have perfect foresight.

[11]Hott and Monnin (2006) find evidence that in the long run house prices go back to a fundamental value that is very similar to the fundamental house price in the present paper.

consideration: Switzerland, Ireland, Japan, the Netherlands, the UK and the US.

3.1 Constant User Costs

In this section we assume that investors do not react to changes in the interest rate. This is equivalent to assume that they do not react to changes in user costs. Instead, they react to their current income and the current supply of houses (or the imputed rent). However, investors forecast that future imputed rents will grow with the constant rate w up to infinity. Expectations about future fundamentals are hence: $E_t^k(H_{t+i}) = (1+w)^i H_t$ and $E_t^k(m_{t+i}) = \bar{m}$, where $i \geq 0$ and E_t^k is the period t expectation according to the *constant user costs* model variation. By making these assumptions, we put more weight on the development of the imputed rents and no weight on the development of interest rates.

Holly and Jones (1997), for example, conclude that income is the single most important determinant of house prices. In our model income is an important driver of imputed rents. Therefore, by putting more weight on the development of imputed rents, the fit to actual prices should improve. Froot and Obstfeld (1991) provide another argument for this. They point out that the part of the (stock) price development that is not explained by the fundamental price is highly positively correlated with dividends. In our model, the imputed rent can be interpreted as the dividend of a house.

Following above assumptions the *constant user costs* house price (P_t^k) is given by:

$$P_t^k = \frac{H_t + E_t^k(P_{t+1})}{\bar{R}} \tag{16}$$

or

$$P_t^k = \frac{H_t}{\bar{R} - 1 + \delta - w + \delta w}, \tag{17}$$

where $\bar{R} = 1 + \rho + \bar{m}$. We calibrate this model variation in the same way as the fundamental house price in section 2.3: We chose parameter values for δ, ρ, $\bar{m}$ and w that minimise the MSE of P_t^k. The results are shown in Figure 3. For comparison fundamental and actual house prices (P_t^* and P_t^a) are displayed as well.

[Insert Figure 3 about here]

As we can see, in some countries and during some episodes, P_t^k can better explain actual prices than the fundamental model. This is especially true for the price bubbles around 1990 in CH and JAP. According to the mean square errors, P_t^k can better explain actual prices than P_t^* in these two countries.[12] This indicates that in these countries investors might have put too much weight on their current income and have not considered that their income might change in the future.

3.2 Speculative Bubble

When it comes to over- or undervaluations of assets speculative behaviour is often named as a possible reason. Under speculation the investment decision is at least partially influenced by expected changes of the corresponding asset price. This could lead to a situation where a price increases only because investors believe that the price will increase in the next period, because they expect that the price will further increase in the period after that and so on.

This idea is formalized by Froot and Obstfeld (1991). The authors look at a typical stock pricing model where the price of a stock depends on the dividend, the price of the stock in the next period and a discount rate. In this setting forward iteration leads to a stock price that is equal to the sum of all discounted future dividends. Froot and Obstfeld, however, show that this present value solution is only a particular solution to the stochastic difference price equation. The general solution is that the price is equal to the present value of future dividends and a (rational) bubble term that has to fulfil several requirements. Now the authors assume that this bubble term only depends on fundamentals. Hence, the dynamic of the bubble is entirely driven by the dynamic of fundamentals.

To be able to introduce this bubble term easily in our model and in line with Froot and Obstfeld, we assume that expectations according to the *speculative bubble* model variation (E_t^b) are equivalent to the expectations according to the *constant user costs* approach: $E_t^b(H_{t+i}) = E_t^k(H_{t+i}) = (1+w)^i H_t$ and $E_t^b(m_{t+i}) = E_t^k(m_{t+i}) = \bar{m}$. Corresponding to Froot and Obstfeld (1991) the general solution of equation (16) is:

$$P_t^b = \frac{H_t}{\bar{R} - 1 + \delta - w + \delta w} + zH_t^{\lambda}, \tag{18}$$

[12]See Table 4.

where P_t^b is the house price according to the *speculative bubble* model, $\lambda = \frac{\rho+\bar{m}+\delta}{w}$ and the parameter z is an arbitrary constant.

The first term of the right hand side of (18) is equivalent to (17) and can be called the present value term. The second term is the bubble term, meaning that as long as z is not equal to zero there is a bubble. Since the development of the bubble term depends on the development of fundamentals, we can expect an overreaction to changes in these fundamentals. Furthermore, if the derivation of the bubble term with respect to the fundamental factor H_t is higher than one, the price effect of an x% above average H_t is stronger than the price effect of an x% below average H_t. This can be seen as a possible explanation for the fact that peaks are often more pronounced than troughs.

Note that z can also get negative and, therefore, there is the possibility of a negative bubble. This stands in contrast to Diba and Grossman's (1988) argument that negative rational bubbles cannot exist because the bubble term has to develop exponential and it is not rational for investors to expect that prices decrease further and further and get negative. However, in our model, as well as in Froot and Obstfeld (1991), the development of the bubble term depends on the expected constant growth rate (w) of a fundamental factor. Hence, not only the bubble term but also the present value term is expected to grow exponentially. If the expected positive path of the present value term overcompensates the negative development of the bubble term, there can be a negative bubble and prices are not expected to get negative in the future.

The *bubble* price P_t^b can be calibrated in the same way as the fundamental house price in section 2.3. Only now we also have to chose the value for the parameter z that leads to the lowest MSE. We do not assume any boundaries to this parameter.

The results of the calibration are shown in Figure 4. As we can see, in most countries the bubble term can help to explain actual house price fluctuations. This is especially true for the house price bubbles around 1990 in JAP and the recent price increase in the NL, the UK and the US. According to the mean square errors, P_t^b improves the fit to actual prices in all but one country (IRL). Note that following equation (18) the fit between P_t^b and P_t^a cannot get weaker than the fit between P_t^k and P_t^a. The reason for this is that z can get zero and, therefore, $P_t^b = P_t^k$. However, for each of the countries the parameter z is positive. Overall, the results indicate that speculation might have been a reason for an over- or undervaluation of houses in some countries. Compared to the results from the *constant user costs* approach the bubble term improves the results especially for the NL, the UK and the US.[13] For these three countries the derivation of the bubble term with respect to the fundamental factor H_t is higher than one. This implies that prices at the peaks deviate more from their fundamental values than prices at the troughs, which is consistent with the general findings in section 2.3.

[Insert Figure 4 about here]

3.3 Momentum Trading

In this section we assume that the past development of house prices has a positive influence on expectations about future prices. Thereafter, investors expect house prices to increase if they have observed that prices increased in the past or if they heard that a neighbor just made a big profit on the investment in a house. Since prices tend to go back to their fundamental value in the long run, expectations cannot solely rely on the momentum of prices. Hong and Stein (1999) develop a model with two types of investors: "newswatchers" and "momentum traders". They show that momentum traders accelerate the reaction of prices to news and that this can lead to an overreaction of the price. In their model momentum traders are very similar to the newswatchers. The only difference is that they base their forecasts on the cumulative price change over the past k periods: $P_{t-1} - P_{t-k-1}$.

To convert this idea in a form that is suitable for our housing model, we assume that the representative investor makes his or her forecasts partially on basis of fundamentals and partially on basis of the momentum of the price. This leads to the following house price:

$$P_t^{*m} = \frac{H_t + (1-\delta)(\mu P_{t+1}^* + (1-\mu)P_{t+1}^m)}{R_t}, \tag{19}$$

where the parameter $0 \leq \mu \leq 1$ reflects the weight the investor puts on the rational forecast (P_{t+1}^*) and P_{t+1}^m is the momentum forecast. This momentum forecast is given by:

$$P_{t+1}^m = P_{t-1}^{*m} \left(\frac{P_{t-1}^{*m}}{P_{t-k-1}^{*m}} \right)^{\frac{2}{k}}. \tag{20}$$

[13] Levin and Wright (1997) examine the impact of speculation on house prices in the UK. Their results suggest that speculation had an significant impact.

This momentum forecast makes medium term price trends more persistent and leads to acceleration of house price fluctuations. The resulting momentum house price P_t^{*m} can be calibrated in the same way as the fundamental house price in section 2.3. Again, we minimise the mean square errors $(P_t^{*m} - P_t^a)$. Only now we also have to chose the value for the parameter μ that leads to the lowest MSE. The lower and upper bound for the parameter μ are zero and one, respectively. This applies to all six countries. For simplicity we assume that k is two years (or eight quarters, respectively) for all six countries. The results of the calibration are shown in Figure 5.

[Insert Figure 5 about here]

Following equation (19) the fit between P_t^{*m} and P_t^a cannot get weaker than the fit between P_t^* and P_t^a. The reason for this is that μ can get one and, therefore, $P_t^{*m} = P_t^*$. As we can see in Figure 5 in CH, the NL, the UK and the US the difference between P_t^{*m} and P_t^* is very small. Here the contribution of the momentum trading is rather small. For IRL and JAP, on the other hand, the consideration of momentum trading improves the fit to actual house prices considerably. This is especially true for the price cycle in the 1970's and the bubble around 1990 in JAP and the recent house price increase in IRL.

3.4 Herding Behaviour

Another possible explanation for the actual development of house prices is herding behaviour. There are various models that explain and describe herding behaviour in asset markets.[14] Lux (1995), for example, develops a model where herding behaviour occurs because there is a positive feedback between the development of the market price and the development of investors' sentiment. Accordingly, the market price increases if the sentiment is getting more positive. The sentiment, on the other hand, increases if there is an excess return. The return itself is positively related to price increases and dividends and negatively related to the price level. If, for example, the price increases there might be an excess return. Now agents become more optimistic. This pushes the price higher and higher. There comes a point where the

[14] For example Avery and Zemsky (1998), Banerjee (1992) or Romer (1993).

price increase is to small to justify the high price level or the low dividend yield, respectively. Now the excess return gets negative, agents get more pessimistic and the bubble bursts.

To model this mechanism, we assume that an optimistic investor demands a risk premium which leads to ρ^+ and a pessimistic investor demands a risk premium which leads to ρ^-, where $\rho^+ < \rho^-$. The representative investor demands a risk premium which leads to:

$$\rho_t = \nu_t \rho^+ + (1 - \nu_t)\rho^-, \tag{21}$$

where ν_t is the weight the representative investor puts on the optimistic view. In other words, ν_t reflects the investors' mood. We further assume that ν_t develops according to the development of the excess return of an investment in houses. The ex post return of an investment in a house is:

$$R_t^h = \frac{H_t + (1 - \delta)P_{t+1}}{P_t}. \tag{22}$$

We define the relevant discount rate of a neutral investor investment as the benchmark return:

$$R^* = 1 + \frac{\rho^+ + \rho^-}{2} + \bar{m}. \tag{23}$$

The excess return is the difference between R_t^h and R^*. If this excess return is positive, investors become more optimistic and if it is negative, they become more pessimistic:

$$\nu_{t+1} = \nu_t + \tau(R_{t-1}^h - R^*)(1 - \nu_t) \quad \text{if } R_{t-1}^h \geq R^* \text{ and} \tag{24}$$

$$\nu_{t+1} = \nu_t + \tau(R_{t-1}^h - R^*)\nu_t \quad \text{if } R_{t-1}^h < R^*, \tag{25}$$

where $\tau \geq 0$ influences the speed of the mood adjustment or how strong the mood reacts on the excess return, respectively.

For simplicity we assume that expectations with regard to future rents and interest rates are the same as in the *constant user costs* approach: $E_t^h(H_{t+i}) = E_t^k(H_{t+i}) = (1 + w)^i H_t$ and $E_t^h(m_{t+i}) = E_t^k(m_{t+i}) = \bar{m}$. The house price under herding behaviour (P_t^h) develops as follows:

$$P_t^h = \alpha \frac{H_t}{\rho_t + \bar{m} + \delta - w + \delta w}. \tag{26}$$

We calibrate this herding price in the same way as the fundamental price in section 2.3. Again, we minimise the mean square errors ($P_t^h - P_t^a$). Only now we also have to choose optimal values for the parameter τ and a starting value for ν_0. For both paramerters the lower and upper bound is zero and one, respectively. For the optimistic and pessimistic parameters ρ^+ and ρ^- we assume that they are equal to the upper (ρ^+=12%) and the lower bound (ρ^-=-1%) of the parameter ρ (see section 2.3). The results of the calibration are shown in Figure 6.

[Insert Figure 6 about here]

As we can see, the herding approach is able to explain the price bubbles in CH, UK and JAP around 1990 and the recent price increase in the UK much better than the fundamental price. Therefore, a possible explanation for the price increases in the late 1980s as well as for recent price increases in some countries is that an excess return from an investment in houses led to a positive market sentiment. The positive sentiment pushed the price higher and higher. Then the price increase got to small to justify the high house price and the bubble burst. This led to a negative sentiment, higher risk premiums and lower house prices. According to the mean square errors, P_t^h improves the fit to actual prices in all but one country (IRL). Note, however, that the MSEs of P_t^h cannot get higher than the MSEs of the constant user costs price (P_t^k). The reason for this is that if τ is zero, the development of P_t^h would be identical to the development of P_t^k. This is the case for JAP.

3.5 Comparison

To compare and judge the different approaches, we compare their mean square errors (MSE) with the MSE of the corresponding fundamental prices. For each country and each model variation Table 4 shows the reduction of the MSE. According to this table, the *constant user costs* assumption only improves the MSE for CH and JAP. For the more sophisticated approaches the results are better: The *speculative bubble* and the *herding behaviour* approach leads to a smaller MSE in all but one country (IRL). Also the *momentum trading* approach lowers the MSE in all but one country (NL). However, the average improvement is smaller than with the *speculative bubble* and the *herding behaviour* approach.

[Insert Table 4 about here]

As we have seen, there are different possible explanations for the high fluctuations of house prices. It is interesting to notice that there is not an approach that is superior for all countries. For JAP, NL and the US the *speculative bubble* approach leads to the lowest MSE. For IRL the *momentum trading* approach is the best and for CH and the UK the *herding behaviour* approach leads to the lowest MSE.

A visual comparison of the different house prices shows that the best explanation for the price bubbles around 1990 in CH and the UK is herding behaviour. The best explanation for the bubble around 1990 in JAP and the recent house price increase in the NL, the UK and the US seems to be speculation and for the recent price increase in IRL it seems to be momentum forecasts.

4 Conclusion

There are numerous studies which show that stock prices fluctuate more than fundamentally justified. In this paper we have shown that this is also the case with house prices. In contrast to the (formerly) widespread opinion that a house is a very safe asset, we have shown that there are substantial over- and undervaluations in the housing market from time to time and that actual house prices fluctuate more than their fundamental values. This implies that there are undesirable price bubbles from time to time.

The theoretical literature offers different approaches to explain excess volatility in stock markets. We have shown that these approaches can also help explaining developments in housing markets. However, their performance differs between the different countries and they are not sufficient to explain the observed bubbles to their full extent. One reason for this is that the model does not consider an important part of the housing market: banks. The willingness of banks to provide mortgages can have a significant impact on the demand for houses and therefore on house prices. This seems to be especially relevant for the recent crisis in the US. Nevertheless, the paper has demonstrated that the behaviour of house investors can be seen as a possible explanation for actual fluctuations of house prices. According to the different approaches, agents overreact to fundamentals and they are influenced by the past development of prices and the past returns on an investment in a house.

Swiss National Bank

A Data

[Insert Table 5 about here]

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Table 1: Average Deviation of Actual (M) from Fundamental (H) Rents and Parameter Values of the Calibration of Fundamental Rents

Country	Mean($\|H-M\|/M$)	α_1	$\hat{d}$	δ	S_0
CH	3.8%	11'742	30	0.06%	11'563
IRL	11.9%	476	11	3.07%	1002
JAP	7.7%	6'632	0.07	0.001%	4'512
NL	5.8%	11'241	0.64	0.001%	9'485
UK	9.1%	8'277	0	0.03%	7'242
US	1.4%	4'810	2.8	0.2%	2'613

Table 2: Fundamental (P^*) vs. Actual (P^a) House Prices

Country	Var(ΔP^a)	Var(ΔP^*)	Mean($\|P^*-P^a\|/P^a$)	Max$\left(\frac{P^a-P^*}{P^*}\right)$	Min$\left(\frac{P^a-P^*}{P^*}\right)$
CH	0.36%	0.04%	13%	45%	-21%
IRL	0.42%	0.26%	32%	84%	-55%
JAP	0.45%	0.07%	10%	30%	-26%
NL	0.71%	0.06%	23%	72%	-29%
UK	0.94%	0.21%	17%	55%	-36%
US	0.11%	0.09%	8%	21%	-12%

Table 3: Parameter Values of the Calibration of House Prices

Country	α_2	ρ	w	$\bar{m}$
CH	0.034	9.4%	0.0%	4.0%
IRL	0.027	5.5%	1.5%	0.5%
JAP	0.036	12.0%	-2.0%	3.5%
NL	0.023	7.4%	3.0%	2.0%
UK	0.008	2.5%	2.5%	2%
US	0.041	12.0%	1.5%	3.0%

Table 4: Reduction of the Mean Square Errors (MSE) by the Introduction of Behavioural Aspects $\left(1-\frac{MSE(P^x)}{MSE(P^*)}\right)$

Country	P^k	P^b	P^m	P^h
CH	6%	5%	6%	32%
IRL	-77%	-63%	58%	-10%
JAP	15%	18%	16%	15%
NL	-121%	57%	0%	9%
UK	-129%	55%	6%	56%
US	-78%	37%	10%	4%

Table 5: DATA DESCRIPTION

Variable	Description	Source	Transformation
Y_t	Real Gross Domestic Product	IMF and OECD	combination of time series and seasonal adjustment by annual growth rates
B_t	Construction of Dwellings (permits: CH, IRL and NL; started: JAP and US; new orders: UK)	Datastream, OECD and SNB	seasonal adjustment by annual growth rates
N_t	Population	IMF	annual data transformed into quarterly by linear interpolation
m_t	Mortgage loans, average rate (except: for IRL 10-y gov sec. yield until 1996 Q1 and for JAP: Long-term prime lending rate)	BIS and OECD	in real terms (divided by CPI growth rate in next 12 month); IRL: 10-y gov sec. yield until 1996 Q1
M_t	CPI housing (CH, IRL and UK) and rent (JAP, NL and US)	OECD	seasonal adjustment by annual growth rates; in real terms (divided by CPI)
P_t^a	Residential property prices (except JAP: residential land prices)	BIS, HALIFAX (UK), OFHEO (US) and Wuest und Partner (CH)	seasonal adjustment by annual growth rates; in real terms (divided by CPI)
CPI_t	Consumer Price Index	IMF	seasonal adjustment by annual growth rates

Figure 1: Fundamental (H) vs. Actual (M) Rents.

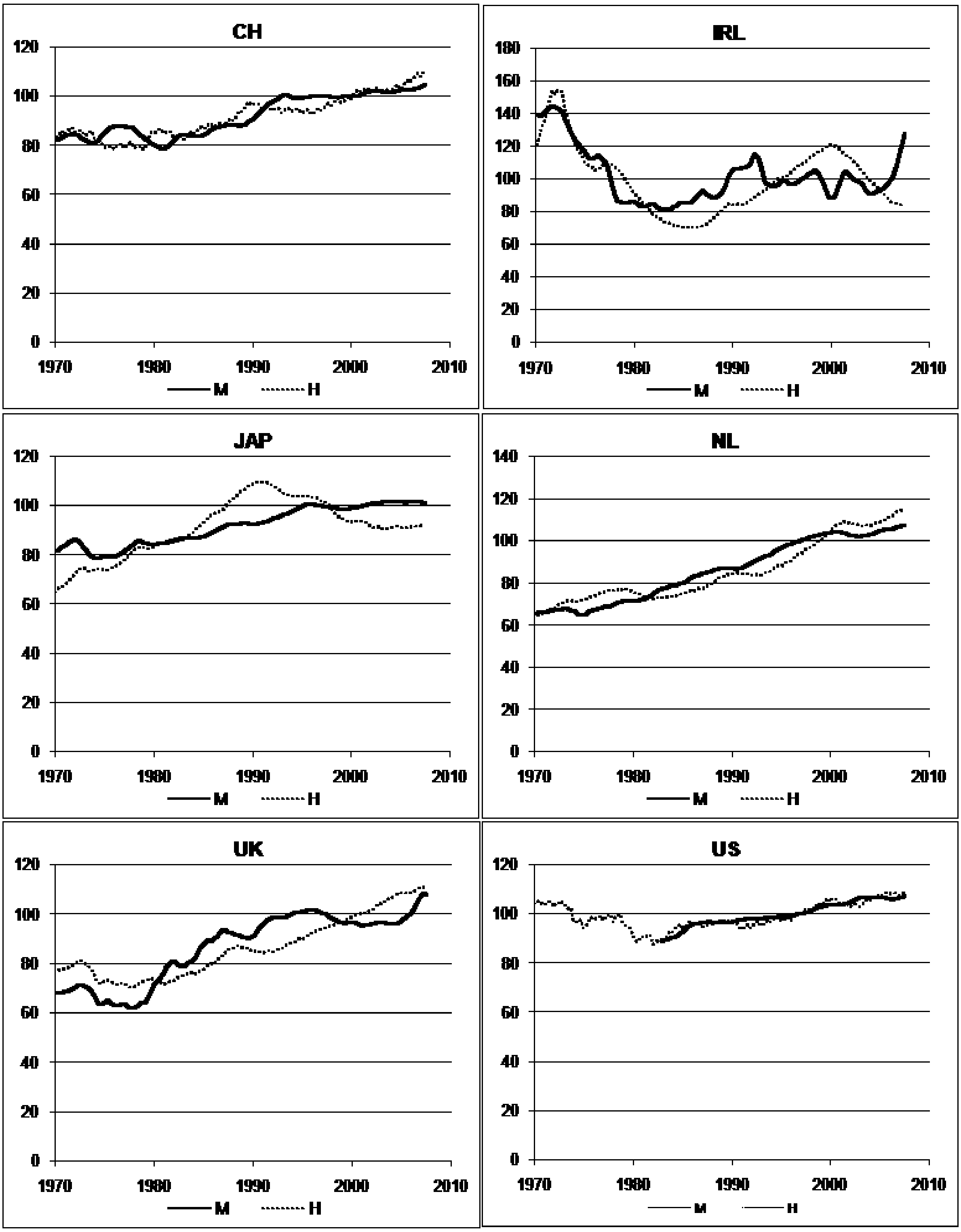


Figure 2: Fundamental (P^*) vs. Actual (P^a)Real House Prices

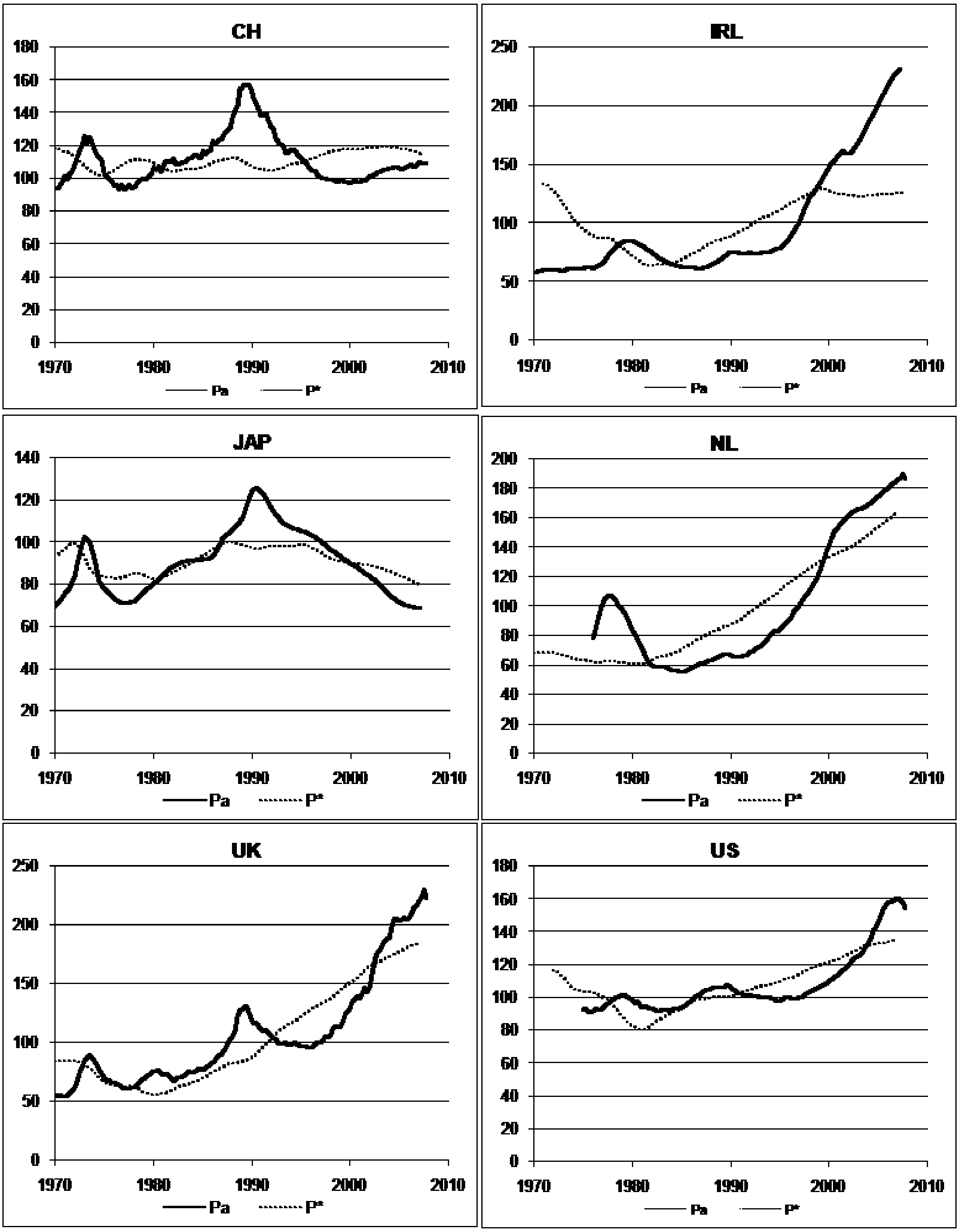


Figure 3: Constant User Costs (P^k), Fundamental (P^*) and Actual (P^a) Real House Prices

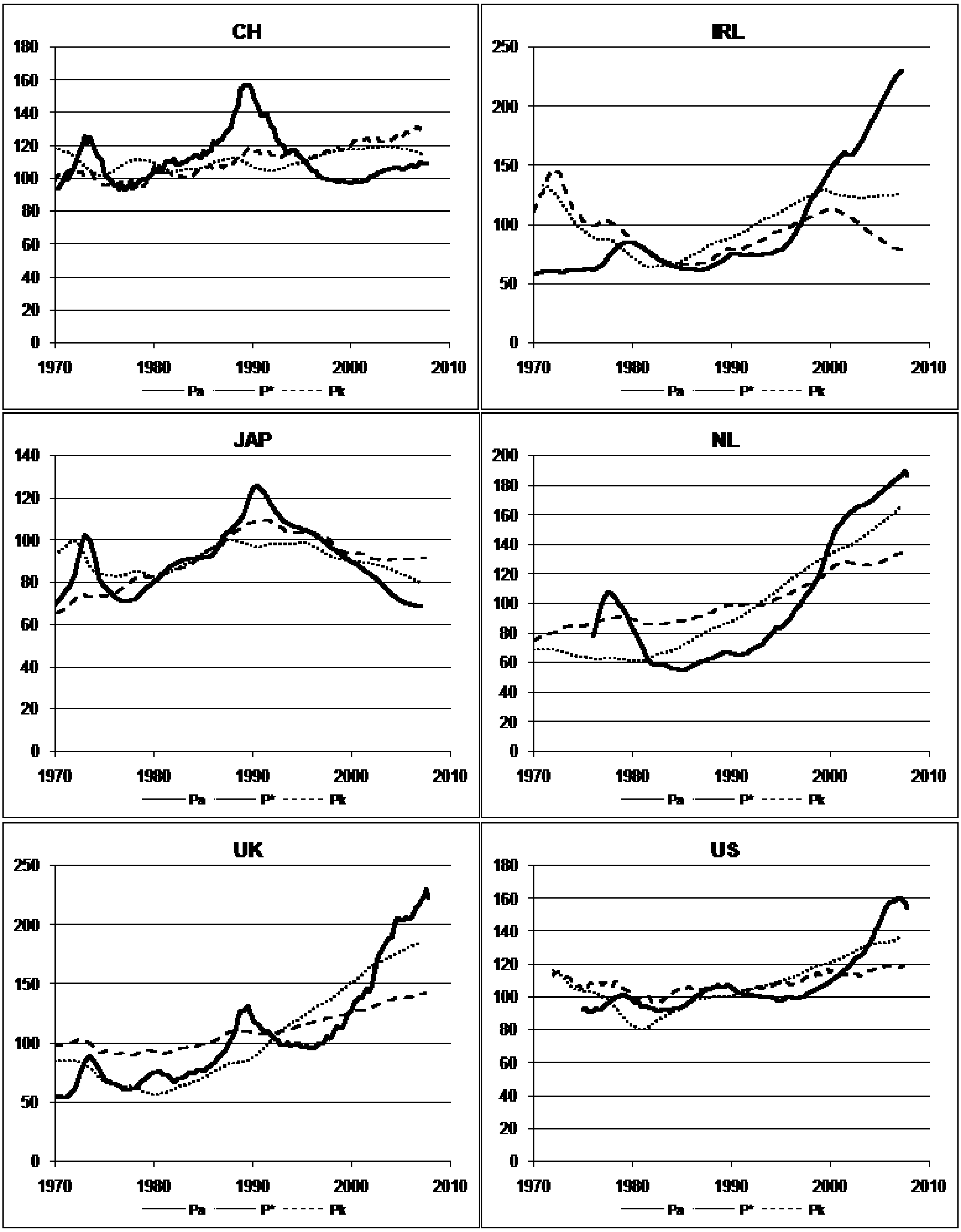


Figure 4: Speculative Bubble (P^b), Fundamental (P^*) and Actual (P^a) Real House Prices

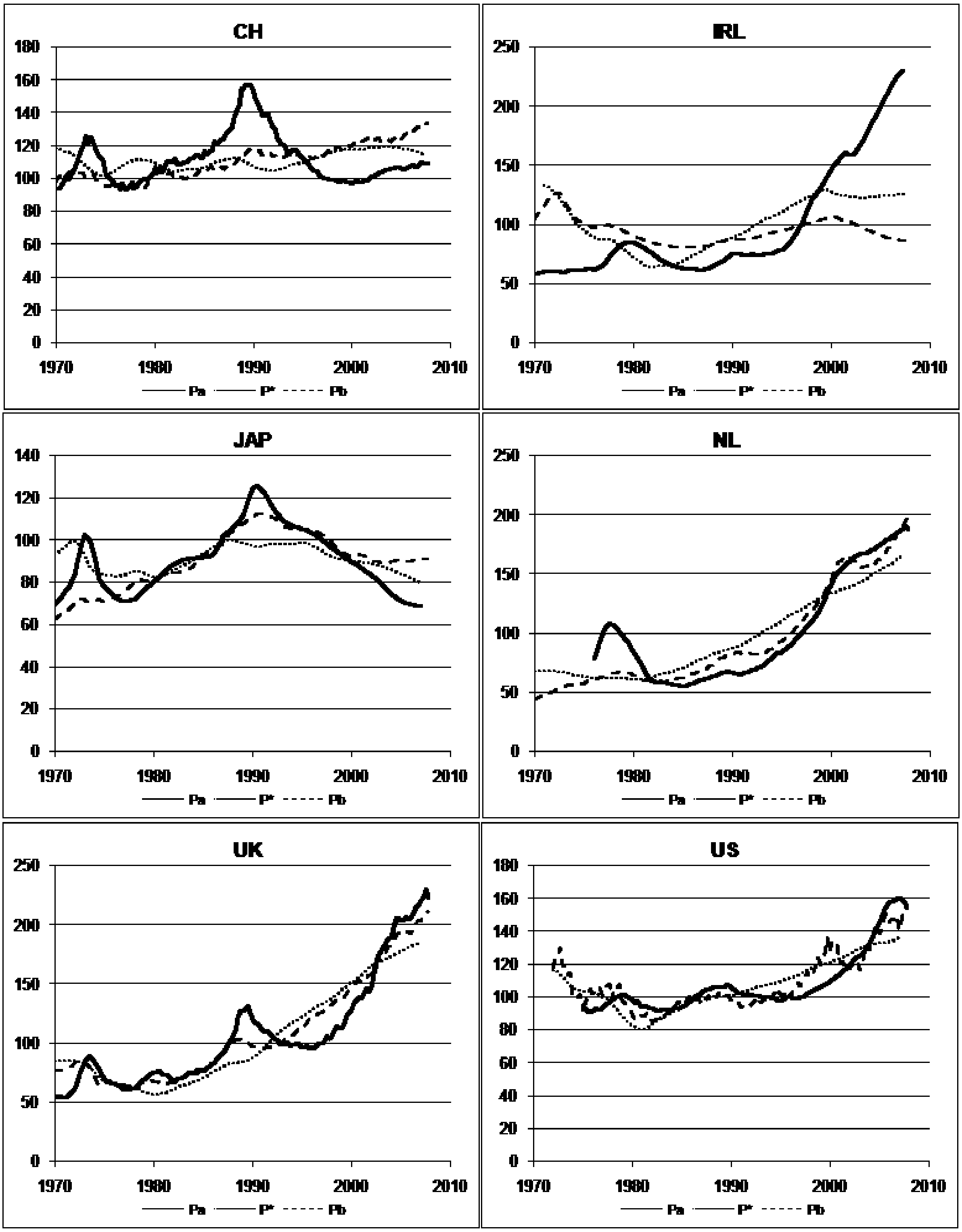


Figure 5: Momentum (P^{*m}), Fundamental (P^{*}) and Actual (P^{a}) Real House Prices

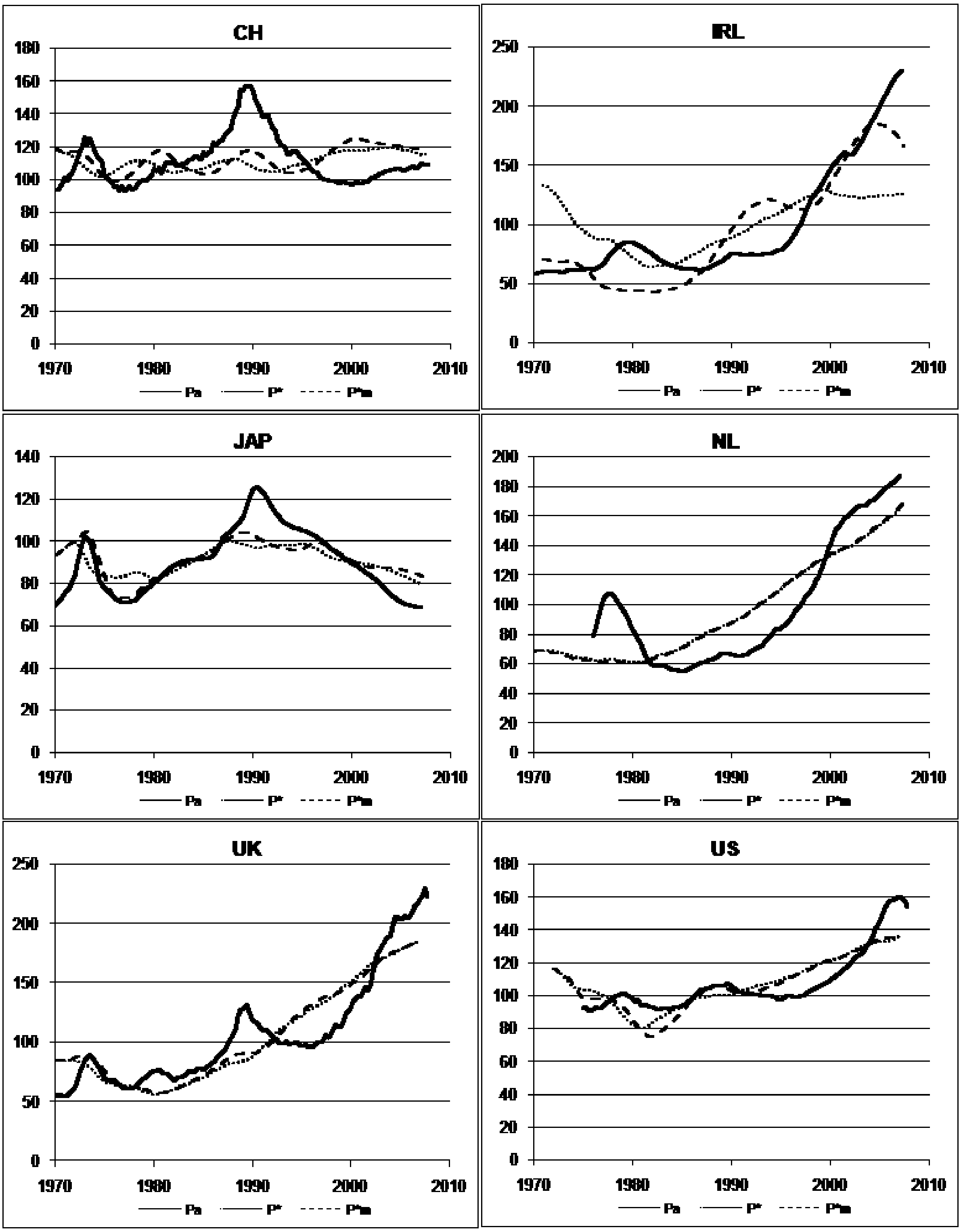
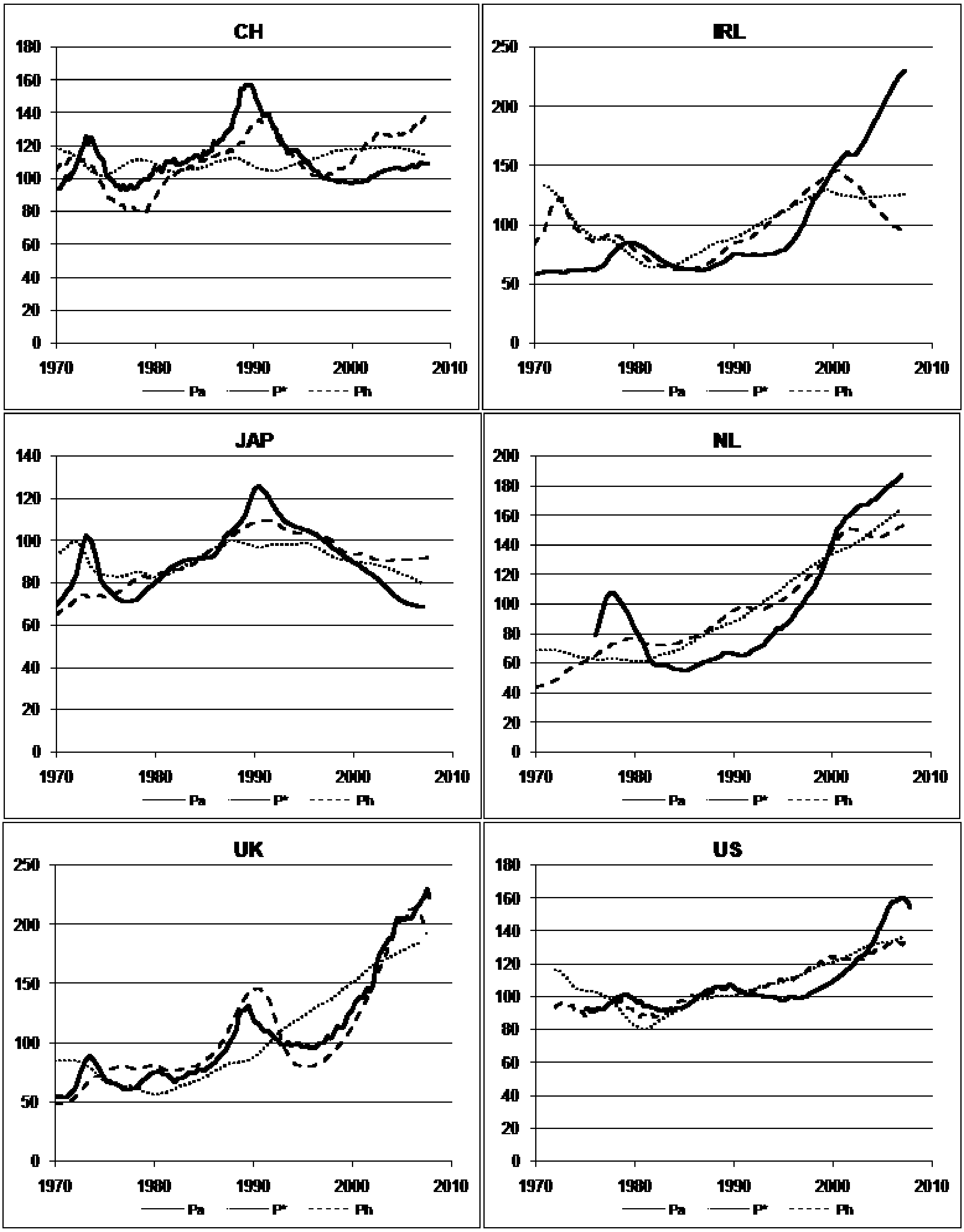


Figure 6: Herding (P^h), Fundamental (P^*) and Actual (P^a) Real House Prices



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