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A global house price bubble? Evaluation based on a new rent-price approach

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A global house price bubble?
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Abstract

The dividend yield ratio in the stock markets is, to an extent, comparable to the rent-price ratio in the housing market. Taking advantage of this definitional similarity, one can then use the traditional unit root test for log dividend yield – in this case, the log rent-price ratio – to test for the existence of real estate bubbles. Such unit root tests are conducted for Finland, USA, UK, Spain and Germany, and the simple test results strongly suggest the existence of bubbles in nearly all of these countries. In addition to this, we develop a continuous and monthly rent-price information-based method to track the periods when real estate prices diverge from their fundamental levels. This indicator seems to work quite well in most cases, indicating bubbles during periods which, according to the consensus literature, are seen as periods of sizable upward or downward shifts in house prices.

Key words: house price, bubble, unit root

JEL classification numbers: G12

Kansainvälinen asuntomarkkinakupla – asuntojen vuokrien ja hintojen suhteeseen perustuva uusi lähestymistapa

Suomen Pankin tutkimus
Keskustelualoitteita 29/2006

Katja Taipalus
Rahapolitiikka- ja tutkimusosasto

Tiivistelmä

Osakemarkkinoilla käytössä olevaa osinkojen ja hintojen suhdelukua vastaavana voidaan asuntomarkkinoilla pitää vuokrien ja hintojen suhdelukua. Tämän vastaavuuden vuoksi osinkojen ja hintojen suhdelukua hyödyntäviä analyysimenetelmiä voidaan käyttää myös asuntomarkkinoiden analysoinnissa. Tässä tutkimuksessa tarkastellaan rationaalisten kuplien olemassaoloa Suomen, Yhdysvaltojen, Iso-Britannian, Espanjan ja Saksan asuntojen hinnoissa erilaisin yksikköjuuriperusteisin testein. Perusyksikköjuuritestien tulokset osoittavat että rationaalisia kuplia on esiintynyt lähes kaikkien testattujen maiden asuntomarkkinoilla. Edellisten testien lisäksi tutkimuksessa kehitetään ja sovelletaan uudenlaista lähestymistapaa, joka perustuu vuokrien ja hintojen tarkasteluun ns. rullaavien informaatioikkunoiden kautta. Tämän menetelmän etu aiempiin nähden on se, että sen avulla pystytään indikoimaan kuukausitasolla, ovatko markkina-arvostukset karkaamassa perusteiden oikeuttamalta tasoltaan. Ensimmäisten tulosten valossa menetelmän tulokset vaikuttavat varsin mielenkiintoisilta.

Avainsanat: asuntojen hinnat, kupla, yksikköjuuret

JEL-luokittelu: G12

Contents

1 Introduction

Recently many reports have expressed concern over rapid rises in house prices. Interestingly these concerns are not focused on one or even a couple of countries, but to on wide set of industrial countries. The same question concerning the sustainability of the present housing price level is being pondered in the US as well as in Europe.

The concern is justified as the behaviour of house prices influences through various channels in the economy. Concerning the regulators point, there are three core aspects, why regulators should be interested about the house price performance and price's possible detachment from the fundamentally justified values, ie the formation of 'house price bubbles'. Concerning monetary policy, an important link between asset prices and policy actions comes through inflation. Academic discussion on this field is focused around a couple of core questions. The first one relates to the asset prices ability to signal for future inflation growth and the second one relates to the overall measurement of inflation. For example Goodhart (1993) has recommended that central banks should replace the conventional inflation measures including prices of goods and services with broader measures that include housing and stock market prices.[1] This proposition has confronted also criticism (see Filardo (2000)[2]).

Another point concerning the regulators view is the linkage between asset prices and their impact to overall stability of the financial system and to banking crises. An important channel in this respect is this liquidity-effect ie the collateral effect. There is a large literature related to the question concerning the financial stability aspect, but to mention few, we could name at least the following: Herrera and Perry (2003), Bean (2004), Mishkin and White (2003), Zhu (2005), Herring and Wachter (2003), von Goetz (2004), Davis and Zhu (2005) and FDIC (1997)). The linkage between house prices and banking crises seems to be largely dependent on the way how banks value the collateral and how collateral appreciation affects their balance-sheets. If their balance-sheets are marked-up, the results might be severe. Related to this practise there are large differences between countries. And when banks are shaking, especially in those cases when banks have a dominant role in the country's financial system, the consequences for the whole economy could be severe.

Finally, the third reason why regulators need to pay attention to housing prices, is the reason related to the overall economic development, especially due

[1] Earlier Alchian and Klein (1973) recommended that asset prices should be included into the price indexes used to measure inflation.

[2] Concerning the housing prices, it is important to notice that according to Filardo's results the housing price inflation does show some power in predicting future inflation, but stock market price inflation exhibits no power at all in predicting future consumer price inflation.

to the resource-allocating effects, wealth effects etc. Of course concerning the wealth effect, the strength of the effect is very much dependent on whether the house price gains are perceived to be permanent or temporary. Another important point is the liquidity of the housing financing system, while it affects how well the households can take advantage of the possible capital gains in house prices (Zhu, 2005). Concerning the economic performance, Helbling and Terrones (2003) found in their research that house price busts are associated with output losses twice as large as equity bubbles and Zhu (2005) reported that increases in property prices were likely to have a positive impact on GDP in many of the countries included in his research, even though the magnitudes varied across sectors and countries. Detken and Smets (2004) analysed various macroeconomic variables in a pre-boom, boom and post-boom phases in the economy and came into the conclusion that not all booms lead to large output losses. They were able to separate some of the features that led into higher cost booms than the others. According to their results 'The booms that were followed by a large recession, and in some cases financial instability, are typically longer, give rise to significantly greater real and monetary imbalances, and, in particular, are characterised by a big boom and bust in real estate markets'. In addition to this the high-cost booms are also characterised by a more positive inflation gap ie larger deviation from its trend.[3]

Large crashes with far reaching effects in the real estate prices are more likely to happen when the prices have been severely mispriced, ie are in bubble. In this respect sound developments in the real estate markets would be crucial. In this research we take a closer look at the recent developments in housing markets in Europe as well as in the USA and provide a novel means to track out the fundamentally unjustified developments in the real estate markets. The novelty in the method developed in this paper relates to the usage of rent-price data, which has only in recent articles been applied to the real estate markets, even though the dividend-yields have been used already for a long time in the equity markets. The method is also novel in a sense that it utilizes the recent research results in the time-series analysis reported by Taylor (2005), Banerjee et al (1992) and applies their results to construct a rolling and frequently updating indicator of unit roots (ie indications of bubbles) in log rent-price ratios. The major advantage of the method is unarguably its ability to evaluate the developments with very short time-intervals instead of being tied to yearly or even longer periods, which previously have been the standard in the real estate related research.

The research proceeds as follows: In the section two we will describe the recent developments in housing markets, describe the reasons why the real estate

[3] For other sources, see for example Helbing (2005), Belsky and Prakken (2004), Benito and Wood (2005), Nothaft (2004), Benjamin, Chinloy and Jud (2003) and Goldman Sachs report from 2003.

prices have risen so fast, evaluate if there are signs of bubbles in the real estate and housing prices and go through the price formation and the role of fundamentals in the real estate markets pricing.

In section 3 we introduce the basic dividend yield based approach measuring the unit roots in the data and how it could be used in the real estate context. In addition to this we will perform the first simple unit root tests to the country-data. In the end of the section we will present the novel price-rent based bubble indicator. In section 4 we will test the method's indicating power by using the data from real estate markets of 5 countries as well as from the US in a regional level. Section 5 concludes.

2 Recent developments in the housing markets

House prices have risen strongly during the last eight years in most of the industrialised countries, although recently there have been some signs of cooling down in some countries, especially so in the UK. In the US the performance over the last 10 years has been amazing: according to the OFHEO (the Office of Federal Housing Enterprise Oversight)-house price index the annual growth rate during these ten years has been 5.4% on average, being 68.9% over the whole 10 years period (see for example Krainer and Wei, 2004). Since 1995 the increase have been roughly double the increase seen in the previous home price booms in the late 1970s and late 1980s as pointed out in McCarthy and Peach (2004) and from the fourth quarter of 2004 through the fourth quarter of 2005 the average US home prices increased by 12.95%. This despite of the fact that some of the recent indications have shown signs that a slowdown in the US housing markets might be forthcoming. Of course, there are very sharp regional differences in the house price developments within the US, while in some states (for example coastal areas) prices have risen much faster than for the whole nation.

Even though the rise in the US house prices has been very strong, the growth in the prices has been even stronger in Europe.[4] Price rises have been very strong in France, Spain, and Ireland as well as previously in the UK and in Netherlands, where the year 2001 witnessed one of the greatest increases in Europe. In 2004 also Belgium, Italy, Sweden, Denmark, Finland and Portugal saw price increases between 5–8%. But there are large differences between the developments in different countries in Europe. For example in Germany the housing-market

[4] As mentioned in the ECB (2003) report on structural factors in the EU housing markets, in most of the countries there can be spotted long cycles in the house prices around a moderate upward trend.

developments have been stagnant for years, but just recently it has shown some signs of picking up.

2.1 Reasons for housing market pick-up

As a main factor for the strong price rise in Europe can be seen the generally low interest rate level (both in real and in nominal terms), which in many European countries has induced the house prices to rise at a faster rate than either the overall economic growth or households' disposable incomes as mentioned in the RICS report (RICS, 2004 and 2005). Due to the low interest rates people have been more eager to accept larger debts in order to buy a house of their own and this development have given support to the price rise. From the RICS statistics, it can actually be spotted that the prices have been rising especially strongly in those European countries, where the mortgage rates are based on short-term interest rates (Spain, UK and Ireland) and where the interest-rates of mortgages have therefore been rather low as the short-end of the yield curve has reacted strongly to the interest-rate level changes. In addition to the interest-rate developments, also the economic developments have seemed to be quite stabile until recently, and this on its behalf has helped to boost consumer confidence.

Similar reasons are on the background of the price growth in the US as well, where the main driver for the increased mortgage-demand has been the low interest-rate level. Indeed, prevailing interest rate-level does seem to have a dominant effect concerning the mortgage-demand: in the UK, where the long boom in the housing prices came into halt in the summer 2004, the reverse in the prices was mainly a result from series of interest rate rises by Bank of England.

Concerning the interest rates, it is worth making a difference between the nominal and real interest rates. During the last couple of years these two have been both very low. Most of the spending decisions are made based primarily on real interest rates, but the housing market seems to be significantly affected by the nominal interest rates.[5] Commonly the relationship between nominal interest rates and the amount of debt is held to be negative as higher nominal interest rates are seen to increase the debt service ratio and this on the other hand reduces the amount of debt individuals are willing to take. An increase in the real interest rates also reduces debt through two channels: higher real interest rate increases the price of the current consumption and higher interest rates increases also the debt servicing costs. More on the relationship between nominal interest rates and housing prices can be found among others from Arcelus and Meltzer (1973),

[5] See for example the remarks by governor Laurence H. Mayer on 'affordable housing' before the National Association of Affordable Housing Lenders' 1997 Northeast Regional Conference in Boston on September the 4th 1997.

Muth (1986), Pozdena (1990) and Painter and Redfern (2002). Concerning housing demand and its relationship to real mortgage rates we could mention for example Titman 1982, Harris 1989 and Van Order and Dougherty 1991.

2.2 Bubbles in the housing prices: the role of fundamentals

Strongly rising real estate prices often lead to speculation and headlines, that there are bubbles developing to house prices. A core question then is, how can one say that the real estate prices are in bubble? This question is the same as asking, how can one say that prices are detached from their fundamentally justified level? Giving a proof for detachment of prices from the fundamentally justified level is not a simple job to do as there are no common agreements of the factors which actually establish the fundamental price in the real estate markets. The pricing process in the real estate markets is regarded as a relatively complex process where expectations as well as real economic variables together form the final market price. Among the core variables, which are seen to affect the pricing of the real estates are the following: household incomes, interest rates, supply (especially so in the short-run), financial market institutions, demographic variables, availability of credit, taxes, public policies directed to housing etc. (see for example ECB 2003, Lamont and Stein 1999, Tsatsaronis and Zhu 2004 and IMF's WEO 2004).

It is true that the housing markets are very vulnerable concerning possible mispricing. As Krainer and Wei (2004) mention: 'Most market participants have little experience, making transactions only infrequently. Asymmetric or incomplete information between buyers and sellers about demand and prices is acute … matching of buyers with sellers is cumbersome and slow. And unlike other markets, there are no good ways to 'short' the housing markets if prices get too high'. It is thought that especially the inexperience and infrequency of part of the market operators could increase the risk of housing markets mispricing.

One way to approach the fundamental value in the real estate markets would be to examine the rent-price ratios in the markets. As known, in a sense rent-price ratios can be seen to correspond the dividend-yields in the stock markets as dividends and rents both represent the underlying capital component ie uncertain future capital flows associated to the asset. In the financial literature the asset's fundamental value always equals the sum of its future payoffs, each being discounted back to its present value by investors using rates that reflect their preferences (see for example Krainer and Wei, 2004). In the stock markets this relationship is between discounted dividends and stock prices, but in the housing market this relationship could be thought to exist between rents and house prices, the reasoning being following as described in Krainer's and Wei's (2004) article

'The fundamental value of a house is the present value of the future housing service flows that it provides to the marginal buyer.[6] In a well-functioning market, the value of the housing service flow should be approximated by the rental value of the house.' This meaning that the price of the house should be approximately the discounted future flow of rents that it would give, if it would be rented. Earlier for example Himmelberg, Mayer and Sinai (2005) as well as McCarthy and Peach (2004) have operated with the rent-to-price (price-to-rent) ratios.

When using the rent-price ratios, also the bubble-concept would become easier to define: the developments in the house prices or rents should not differ too much from each other, while otherwise this would mean that bubble would appear in the housing markets.

It sounds temptating and easy, but it must be noticed, that there are some important differences between rents and dividends, which actually can severely affect the way how well they truly compare with each other. The first difference comes through the way the dividends and rents are dependent on underlying price-developments. In the stock markets, arise in the stock's price level signalises of expected higher earnings and therefore higher dividends. In the housing markets the chain of events goes a bit differently: the price rises in the markets actually advance the rent arises which then happen with a lag compared to the price developments. Another important difference is the way how the decisions on dividends and rents are made: dividends are decided by the board of a firm (possibly according to varying motivators) while the rents realising in the markets are an outcome of a negotiation process.

In the section 3 we will present the fundamental model constructing the bubble-test for the rational bubbles in the housing markets. Originally this approach has been developed to stock markets, but if we assume that we can handle dividends and rents similarly ie both representing the uncertain future cash flows associated to an asset, we can apply the same test of unit-roots also to the housing markets. But as pointed out in various articles, this might approve problematic mainly for two reasons: in the unit-root testing method the rents are supposed to move freely without any restrictions. This is not completely true in reality as there are rent-controls in many of the countries where we have data from. In most of the countries rents have been less restricted only since the mid 1990s, meaning that before this the rent-level has been too sticky compared to the changes in the price-level. In many countries also the social sector in rental markets might be rather large, affecting therefore also to the average rental-levels appearing in data. This could lead to very susceptible indications of bubbles, while the relationship between the rents and prices would break down quite easily leading then to the indication of a bubble in our method. Due to its importance, the rent-control is more thoroughly handled in the Appendix 1. In this appendix

[6] It must be noticed that this argument ignores the potential effects of taxation.

we will also present the list of major regulatory changes concerning the rents in Europe, as they do affect the way the country-level indications should be interpreted. The second reason is that when we are operating with the raw-data, it is not possible to take into account the impact of taxes or interest-rates in the rent-price ratios and this might bias the results from the unit-root tests.[7]

2.3 Are there signals of bubbles in the real estate markets?

Related to the current market situation in the housing-markets, are there then some worrying features present? We have noticed in several countries a strong price-upheaval, but this might be partly explained through low interest rates and therefore increased attraction towards ownership, at least in the short-run.

Concerning the bubbling features, we do have some interesting information for example from the US. One of these features has been the enormously increased faith to continuously rising prices. As history has shown, the basic reason for the bubbles has always been the speculation and related to it the growing overconfidence among the market players: people have become too confident that this 'sure thing' will always make them money. This feature has been documented lately in the housing markets, for example by Case and Shiller (2003). Case and Shiller did a survey for 2000 households who bought homes in May 1988 as well as to comparable group who bought home between March and August 2002. The results from the 1988 survey provided strong evidence, that there existed a bubble in the 1988: 'buyers were influenced by an investment motive, that they had strong expectations about future price changes in the housing markets, and that they perceived little risk … emotion and casual word of mouth played a significant role in home purchase decision. In addition, there was no agreement among buyers about the causes of recent home price movements and no cogent analysis of the fundamentals.'

Compared to this the situation in the US in 2003 looked quite similar in few respects: once again housing was seen as an investment, even though less so in 2003 than in 1988. Concerning the riskiness, only small amount of buyers thought that housing markets involved a great deal of risk (though there appeared some regional differences) and the absolute majority of the answerers did see some or little/no risk. The expectations of the future price performance were high in 1988 as well as in the 2003 survey: approximately 90% of the respondents expected the prices to increase during the next several years.

As a bit alarming we could also held the expectations concerning the long-run price changes: the aggregate response of yearly price change was over 12% in

[7] In the future work we are taking into account the impact of taxes and interest rates and exploring their effects to the results.

2003, compared to clearly minor percentages in 1988. Based on these results Case and Shiller (2003) concluded that 'these general indicators of the defining characteristics of bubbles were fairly strong in 2003'.[8] Besides Case and Shiller (2003) also Zhou and Sornette (2005) have analyzed the quarterly average sales prices of new houses sold in the US in order to determine whether the prices have grown faster-than-exponential, which they take as the diagnostic of a bubble. Their conclusion is that the 22 states (mostly Northeast and West) exhibit clear-cut signals of fast growing bubble.

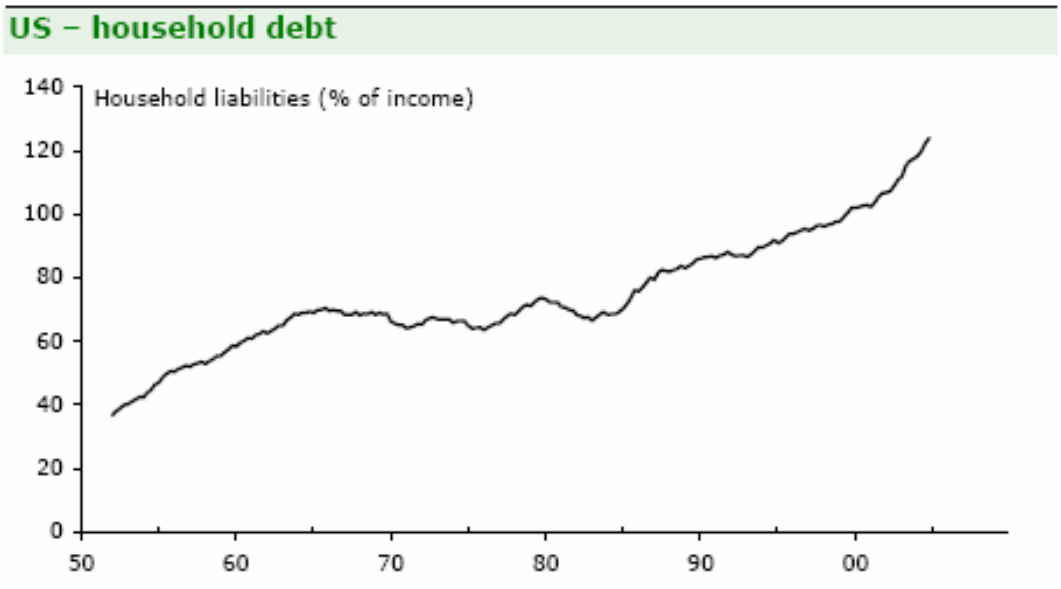
These developments in the US seem to have continued until recently. In March 2005 the New York Times reported[9] that according to the National Association of Realtors 'nearly one-quarter of home purchases last year were made by people who thought of the house as an investment rather than a place to live'[10] and according to the government reports the sales of new homes jumped sharply in February, being the largest monthly increase in four years. Furthermore according to the recent report by the Joint Center for Housing Studies of Harvard University (2005), between 1998 and 2003 the share of home purchase loans made to other than owner-occupants climbed from 7 to 11 per cent.[11] This can partly be held as a signal of speculation in the housing markets. In the spring 2005 also ABN AMRO reported in their overnight report on April 20th,[12] where they quoted an article originally published in the LA Times article, that 'buy now, pay later' – mentality prevails amongst mortgage borrowers who are taking interest-only loans. According to the report these loans accounted already one-third of the new mortgages nationally last year, making it possible for more marginal homebuyers to become a house owners.

The possible problem seems to be, that expectations of the continuing price upheaval could give some indications of possible bubbling pressures. The core question is that if expectations will break down, will this result in problems? One possible source of problems could be the risen ratio of total household liabilities to income (at the moment the ratios of house prices to median household incomes are at their 25-year high in more than half of the evaluated metro areas in the USAs mentioned in the JCHS report). Even though this ratio has risen strongly since the end of 1990s, sofar it has not led to increases in financial stress. In the

[8] But there were regional differences: 'they were generally less strong than in 1988 in the glamour cities and stronger than in 1988 in Milwaukee'.
[9] The New York Times, March 25th 2005: 'Trading Places: Real Estate Instead of Dot-Coms'.
[10] The National association of Realtors conducted the first survey of second-home owners profiles in 2002 through a joint e-mail and mail survey. Concerning the motivations of owning the second homes, nearly 78 per cent were reported to be vacation homes as opposed to investment homes or land in 2002.
[11] Investors operated actively also in the new homes market as they bought 4% of new single-family houses and 13% of condos, as can be seen from the JCHS report.
[12] ABN Amro 'If you can fog a mirror, you can get a home loan…', an overnight report, April 20th, 2005.

ABN Amro's report this is argued to be due to the fact that the ratio arises has been offset by the overall strength in the economy. Core question in this sense will be the future interest-rate developments and thereby also developments in the inflation.

Figure 1. **Household liabilities (% of income)**



Source: ABN Amro's overnight report 20th April 2005.

3 Unit-root based approach

In this section we will prsent the fundamental model constructing the bubble-test for the rational bubbles in the housing markets. The method in this section relies heavily on four sources: to Campbell, Lo and MacKinlay (1997), Campbell and Shiller (1988a and b) as well as to Koustas and Serletis (2005). Concerning the housing market it is probably true that the prices are driven out of their equilibrium values due to the increases in demand, but the underlying motive of the increased demand might not be a speculative one, but might come through few factors: loose financing (meaning easy access to credit), low nominal interest rates, good outlook in personal finances and through a scare that the prices continue to arise further (even if prices would seem high → if don't buy now, won't be able to afford it later).

Concerning the testing-method, let us begin by defining the net simple return of a stock or to an asset as

$$R_{t+1} = \frac{P_{t+1} - P_t + D_{t+1}}{P_t} = \frac{P_{t+1} + D_{t+1}}{P_t} - 1 \tag{3.1}$$

where R_{t+1} denotes the return on the asset held from time t to t+1, P the price of the asset and D the dividend ie rent in the housing markets. The return is not known until period t+1. Taking the expectation of identity (3.1), which is based on information at period t and rearranging, we obtain

$$P_t = E_t\left[\frac{P_{t+1} + D_{t+1}}{1 + R_{t+1}}\right] \tag{3.2}$$

Extending the expression for k periods, yields (note that i = k)

$$P_t = E_t\left[\sum_{i=1}^{k}\left(\frac{1}{1 + R_{t+i}}\right)^i D_{t+i}\right] + E_t\left[\left(\frac{1}{1 + R_{t+k}}\right)^k P_{t+k}\right] \tag{3.3}$$

The last term in the equation (3.3) is the expected discounted value of the asset price k periods ahead. As the horizon lengthens, this term is assumed to converge to zero. This assumption is satisfied unless the asset price is expected to grow forever at rate R_{t+k} or faster. Under the convergence assumption, equation (3.3) can be solved forward by expressing the fundamental value of the asset, F_t, as the expected present value of future rent-flow

$$F_t = E_t\left[\sum_{i=1}^{\infty}\left(\frac{1}{1 + R_{t+i}}\right)^i D_{t+i}\right] \tag{3.4}$$

Abandoning the convergence assumption leads to an infinite number of solutions, all of which can be written in the general form

$$P_t = F_t + B_t \quad \text{as} \quad B_t = E_t\left[\frac{B_{t+1}}{1 + R_{t+1}}\right] \tag{3.5}$$

ie the price comprises the fundamental value plus the component B_t, which denotes a rational bubble.

So far expected asset returns were assumed to be constant. Though this assumption is convenient, it contradicts with the reality as the expected returns to an asset are time-varying, making the relationship between prices and returns nonlinear. To overcome the problems due to nonlinearity, Campbell and Shiller (1988a) suggest a loglinear approximation.

The loglinear approximation is given by

$$r_{t+1} \approx k + \rho p_{t+1} + (1-\rho)d_{t+1} - p_t \quad [13] \tag{3.6}$$

Approximation (3.6) holds exactly when the log rent-price ratio is constant as then d_{t+1} and p_{t+1} move together one-to-one. Equation (3.6) is a linear difference equation for the log asset price and it is analogous to the linear difference equation for the level of the asset price with returns expected constant. In similar way as before, we can impose the no-rational-bubble terminal condition. Solving forward equation (3.6) and imposing the no-rational-bubble terminal condition we obtain

$$p_t = \frac{k}{1-\rho} + \sum_{j=0}^{\infty} \rho^j \left[(1-\rho)d_{t+1+j} - r_{t+1+j}\right] \tag{3.7}$$

Equation (3.7) shows that if the asset price is currently at a high level, then there must be some combination of high rents and low asset returns in the future. This holds ex post, but also ex ante. For the ex ante version, we can take expectations of (3.7) and take into account that $E_t[p_t] = p_t$, to get

$$p_t = \frac{k}{1-\rho} + E_t\left[\sum_{j=0}^{\infty} \rho^j \left[(1-\rho)d_{t+1+j} - r_{t+1+j}\right]\right]. \tag{3.8}$$

Equation (3.8) is a dynamic generalisation of the Gordon formula.[14] The main difference is that in the dynamic formula the effect on the asset price depends on how long the rent growth rate is expected to be high or the discount rate low. Finally we can rewrite equation (3.8). Instead of using the log asset price, we use the log rent-price ratio to get

$$d_t - p_t = -\frac{k}{1-\rho} + E_t\left[\sum_{j=0}^{\infty} \rho^j \left[-\Delta d_{t+1+j} + r_{t+1+j}\right]\right] \tag{3.9}$$

We focus now on equation (3.9). Recalling that Craine (1993) pointed out that if Δd_t and r_t are stationary stochastic processes, then the log rent-price ratio, $d_t - p_t$, is a stationary stochastic process under the no-rational-bubble restriction. Therefore, if we can find a unit root in the log rent-price ratio, this is consistent with the existence of rational bubbles in asset prices in the case when Δd_t and r_t are stationary and stochastic processes.

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[13] Here $k \equiv -\log(\rho) - (1-\rho)\log(\frac{1}{\rho-1})$ and $\rho \equiv \frac{1}{[1+\exp(\overline{d-p})]}$.

[14] With the expectation of constant required returns and constant dividend growth.

Results of the simple unit root tests to the log rent-price series can be seen from table 2. According to these tests we can not reject the unit root hypothesis in any of these cases (except for the UK in case when trend is included), meaning that there has been a bubble or bubbles in the real estate prices in these countries during the periods in focus. It must be noticed, that in Germany the rejection in the augmented Dickey-Fuller is quite close though as the t-value is quite close to the critical value.

3.1 Rolling augmented Dickey-Fuller test as an indicator

A drawback in the previous test procedure is that the simple unit root test answers only the question whether there is a bubble or possibly bubbles in the asset price data during the whole period which the tested data covers. It is not capable to separate when bubbles exactly take place. This is why our next focus will be to try to localize the possible existence of bubbles more exactly from the 'dividend yield' time series data. In order to do this we will develop a completely new method based on an indicator constructed by using the ordinary augmented Dickey-Fuller method. In order to get frequently updating indicator, we will estimate the ADF by using a rolling window of 12 data observations.

In order to test for the existence of unit-roots in the log rent-price ratios with the augmented Dickey-Fuller in equation (3.9), we should first choose the appropriate lag-structure for the augmented Dickey-Fuller regression. With the ADF we are able to control for higher order correlation. After diagnostic analysis the augmented Dickey-Fuller regression to be used in testing for the non-stationarity of the log rent-price ratios would be (3.10).[15] This regression is used in rolling sub-samples.

$$\Delta(d-p)_t = \mu + \gamma(d-p)_{t-1} + \delta_1\Delta(d-p)_{t-1} \qquad (3.10)$$

[15] A bit problematic is that the rolling method treats all periods alike and cannot separate between possible regime shifts. On the other hand, if the regime shift affects other factors than fundamentals and causes a strong price reaction in the real estate market, shouldn't this be treated as any other pressure towards pricing? Therefore it would be justified to measure the building pressures by the unadjusted rolling estimator.

Table 2. **Tests for integer orders of integration**

Country	Variable	Data	t-value	Lags	5% critical val.	Conclusion
Finland	d_t–p_t	Quarterly	-3.504 (ADF)	4, SIC	-3.441	H(0) rejected, no unit root
		Q1.81–Q4.04	-2.026 (ADF)	5, SIC	(C+T)	H(0) valid, unit root in d_t–p_t
			-1.382 (PP)	8, NWu.B	-2.881 (C)	H(0) valid, unit root in d_t–p_t
					-2.881 (C)	
Germany	d_t–p_t	Quarterly	-2.603 (ADF)	5, SIC	-2.881 (C)	H(0) valid, unit root in d_t–p_t
		Q1.68–Q4.04	-1.491 (PP)	6, NWu.B	-2.881 (C)	H(0) valid, unit root in d_t–p_t
Spain	d_t–p_t	Quarterly	-0.671 (ADF)	2, SIC	-2.904 (C)	H(0) valid, unit root in d_t–p_t
		Q1.87–Q3.04	-0.635 (PP)	6,NWu.B	-2.903 (C)	H(0) valid, unit root in d_t–p_t
UK	d_t–p_t	Quarterly	-2.168 (ADF)	1, SIC	-2.892 (C)	H(0) valid, unit root in d_t–p_t
		Q2.68–Q4.04	-1.720 (PP)	6, NWu.B	-2.892 (C)	H(0) valid, unit root in d_t–p_t
USA	d_t–p_t	Quarterly	2.122 (ADF)	1, SIC	-3.462 (C+T)	H(0) valid, unit root in d_t–p_t
		Q1.83–Q4.04	2.868 (ADF)	1, SIC	-2.895 (C)	H(0) valid, unit root in d_t–p_t
			3.046 (PP)	5, NWu.B	-2.895 (C)	H(0) valid, unit root in d_t–p_t

ADF in the tests refers to Augmented Dickey-Fuller and PP to Phillips-Perron unit root test. In the PP the bandwidth is chosen through Newey-West using Bartlett kernel (NWu.B) and in ADF the lag is chosen through Schwartz Information Criteria (SIC).
We have either included a constant (C) or constant and trend (C+T) to the tests.

Our primary interest in the regression is the value of the coefficient γ, as it can be interpreted as signalling non-stationarities in the log rent-prices. As known, the augmented specification is generally used to test whether $H_0{:}\gamma = 0$ holds (H_0 accepted) against the alternative hypothesis $H_1{:}\gamma < 0,\ \gamma \geq 0$, thus, being an indication of explosive ie non-stationary process, when the residuals are normally distributed. This leads to a very simple interpretation: a value of coefficient γ greater than zero would indicate periods where dividend flows do not match the asset price level. In another words, such values would indicate the presence of bubbles in asset prices.[16]

Of course, we could have operated with critical t-values instead of using only 0-level, as is usually done with the augmented Dickey-Fuller tests. Problem is, that in that case we should have taken into account the small sample-sizes in choosing the critical t-values and those critical t-values should have been simulated. More information about the chosen method with 0 as the critical level, method's statistical reliability and statistical characteristics can be found from Taipalus (2006), where we gore more thoroughly through the method in the stock market context and perform simulations in order to test out the method's reliability and unbiasedness.

3.2 Data

The data used in this research includes price indices as well as rent indices from each of the countries in focus. As mentioned in many references, for instance in McCarthy's and Peach's (2004) article, in ECB's (2003) article as well as in RICS's European housing review (2004), there are many weaknesses related to the usage and construction of these indices. Solely related to the price-indices we could list the following weaknesses: the underlying data comes from various sources and the statistics are compiled in various ways, the houses are heterogeneous assets and their qualities vary and in addition there are short-term fluctuations (seasonality etc.) that are not necessarily reflecting any long-term changes in house price trends and the differences in statistics between countries are large (non-harmonized national data, differences in coverage). Indeed, comparison between different countries is very difficult. Same problems relate to rent-statistics.

As we are using this data to measure when there are bubbling pressures in the real estate markets, these weaknesses have an affect on those evaluations as well.

[16] One drawback is that the distribution of residuals from the regression in our data is not precisely normally distributed. The residual distributions did show significant kurtosis compared to the normal distribution, more about the distributions by country-level can be seen from Appendix 2.

Therefore the results should be interpreted with certain caution due to these basic flaws in the data.

Table 3 describes our data in more detail. Most of the rent-information was taken from the OECD-database in order to reach some commensurability.

Table 3. **Basic data used to calculate the D/Y (= rent index/price index)**

Country	Price-index	Rent-index
USA	Office of Federal Housing Enterprise Oversight (OFHEO) House Price Index (HPI) for period 1983Q1–2004Q4. 'the HPI is a broad measure of the movement of single-family house prices'. For more: www.ofheo.gov	a) OECD main economic indicators, the housing-component from CPI. It must be noticed that OECD's data is not the pure rent-data. b) BLS's (Bureau of Labour Statistics) owner's equivalent rent of primary residence-component from CPI. Aggregated to quarter level by Bank of Finland's statistical program and indexed as 1983Q1=100. for more: www.bls.gov
Finland	House Price Index from Statistics Finland, period 1981Q1–2004Q4.	Rent-information: CPI's rent component. This information includes also water, heat etc. Information from Statistics Finland.
Spain	House Price Index -information was originally in form euro/sq. meter. Information is from the web-pages of Ministerio de la Vivienda www.mviv.es. Period: 1987Q1–2004Q4.	OECD's Housing component from the CPI.
Germany	(Single family) House Price Index from Statistics Germany. Aggregated to the quartal-level by the statistical program of Bank of Finland. Period: 1968Q1–2004Q4.	OECD's Housing component from the CPI. Buba publishes pure rent-series, but this information is relatively short. When compared, the OECD's and the Buba's rent series did not differ very much.
UK	House Price Index from Office of Deputy Prime Minister. Period: 1968Q2–2004Q4.	OECD's Housing component from the CPI. Pure rent-series is available, but only since 1996.

4 Results from the rolling sub-sample ADF-indicator

In order to have a quarterly updating value of the indicator, ie the coefficient γ in the ADF-regression, we should have a rolling window of data observations that are used for the estimation of the regression (3.10). By a 'window' it is meant the length of the sample of the log rent-price ratio data that will be included in the estimation of the ADF-regression at a time. The data where we base our estimations on is the data of price-rent ratios, which was already introduced in the section 3.2.

Concerning the length of the window ie the sub-sample, we tried out several possibilities. After statistical deduction it seemed that the 12 quartals (3 years) rolling window (meaning that the regression (3.10) is always estimated by using last 12 quartals dividend yield data) gave us useful indications in the sense that the indications from the shorter window-periods focused around and on the indications given by the 12 quartals rolling period. Concerning the time series properties it must be taken into account that in order to have robust results the period chosen to be included into the regression estimation window should be as long as possible.[17] This is a serious scarcity concerning our method where we estimate a regression using only 12 observations.[18]

Regarding the bubble-indications, given by the coefficient γ, it is important to notice that bubble-indications don't realise only when prices are rising at higher pace than could be justified according to the rent flow (as was the case in positive rational bubbles), but also when prices are descending faster that could be justified according to the rent flow. This is due to the fact that the underlying model behind this theory is the present-value pricing formula, according to which the prices and dividends (here rents) should be cointegrated. This does not happen when the relationship is explosive ie when the $\gamma > 0$. In this sense this indicator should be able to react to either large over- or undervaluations in the market prices compared to their fundamentals.

Next we can take a closer look at the bubble-indications given by the ADF-based indicator. As we remember, any time when $\gamma > 0$ in case of a normal distribution, we held this as an indication of a bubble in the markets, while according to the present value model, in these cases the level of the rent flow does not correspond the price level prevalent in the markets.

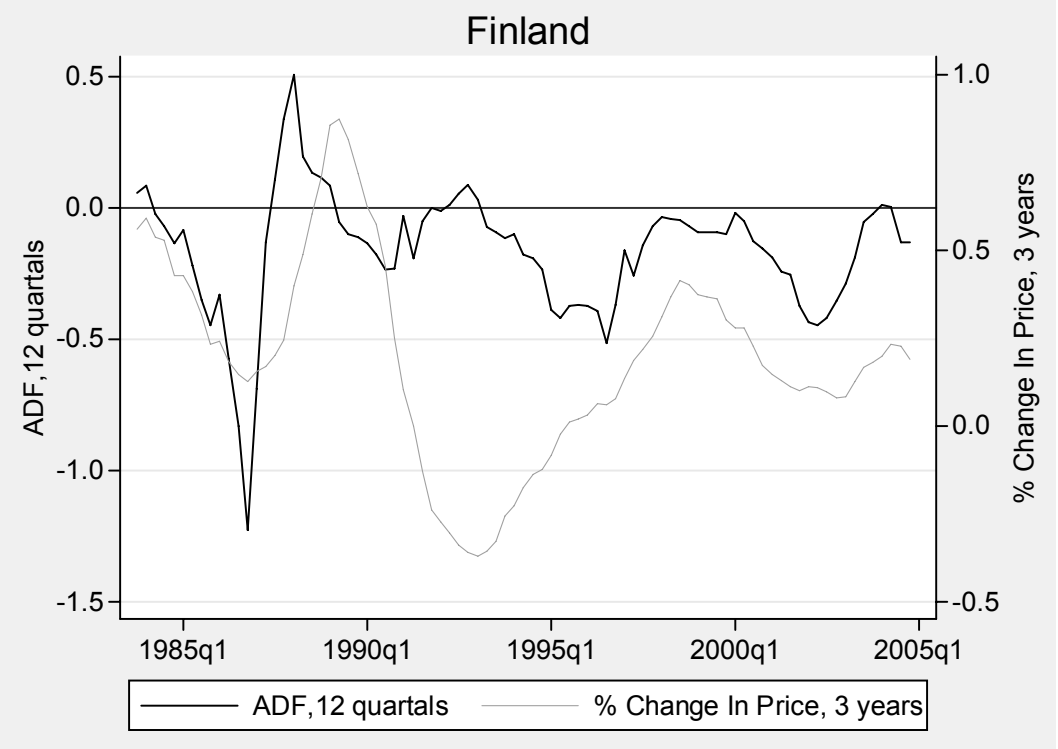
[17] Using this method, the parameter γ-values are always tied to the last month included to the data window.
[18] Window lengths and results sensitiveness to these choices is more thoroughly gone through in Taipalus (2006).

4.1 Country-level evidence

The periods identified as bubbles by the 12 quartals rolling window indicator for the Finnish, German, Spanish, UK and US real estate markets are presented in figures 3, 4, 5, 6, 7 and 7 (we modified the quartal data into a monthly data through a statistical program and counted the indications for rolling 36 months data, these results are presented as figures A2.1-A2.5 in Appendix 3).

Indicator-graphs, figures 3–8, show the bubble-indications together with price-index information. The added price-index information is the cumulative % -changes in the price indices over the 12 quartals period.

Figure 3. **Real estate bubble-indications, Finland**



Looking at the figure 3, we can spot four periods signalized as bubbles in the Finnish real estate markets. These periods are the following: from late 1983 until the early 1984, from autumn 1987 until early 1989, from spring 1992 until early 1993 and finally a period that starts somewhere round autumn 2003 (gets very close to 0) and lasts until summer 2004. All of these periods are related to strong arise in the price index, except for the one in the beginning of the 1990s, which

could be held as an indication of a negative bubble ie signal that the prices of the properties have corrected too strongly downwards compared to the rent-level.[19]

According to Laakso (2000) the housing markets at national and regional levels experienced dramatic changes during 1980s and 1990s in Finland. Especially housing prices and housing construction experienced a boom in the second half of 1980s and a collapse in the beginning of 1990s. It is worth noticing that according to Laakso, there is no evidence on a major price bubble, but the boom and the collapse of prices could mainly be explained through the developments of income, employment, interest rates and vacancy rates. According to him also the liberalisation of financial markets and the accumulation in credit had a significant effect on housing price boom.

Concerning the bubble-indications, the first period (from late 1983 until the early 1984) is rather hard to link to any economic booms. On the other hand a lot easier is to link the next indication from autumn 1987 until early 1989 to the overall economic development. The growth in the real estate prices during this period was exponential: the real prices rose 60% from the second quartal of 1987 until the first quartal of 1989. This period matches well to the bubble-indication given by the ADF-coefficient. The given indications appear not so surprising if we take a look at the rent-markets at the time. The rents did not rise as strongly during the last years of 1980s as did the prices due to the rent-control,[20] the only exception was that the decrease in the rents stopped during the real estate price boom. Rent-control clearly affects the functioning of the indicator, while strong rises in the price-level and sticky rents lead quickly to break in the cointegrating relationship between these two variables.

Concerning the Finnish data, only the rents from the early 1990s onwards reflects the true pressures in the rent-markets. In this respect it is interesting to notice the negative bubble that the indicator signals for the period starting from spring 1992 and lasting until early 1993. This period is related to the economic crises that Finland confronted in the early 1990s, which was the most severe since the 1930s: The real GDP decreased by 11% during the three years (1991–1993) and the unemployment rate rose from 3% in 1990 to 16% in 1993. The real estate prices reacted by sinking strongly: the crash begun in the autumn 1989 and continued non-stop for four years, reaching bottom in the first quartal of 1993. Once again this period matches well the bubble-indications given by our indicator.

The last period indicated as a bubble by the ADF-based indicator relates to the present phase of strongly rising property prices. According to the indications the bubble has developed to Finnish real estate prices. The bubble-indications were

[19] The early 1990's is a very exceptional period in Finland, it might even represent a regime-shift in a sence.

[20] As Laakso mentions, the amount of rentables decreased strongly during the period when the rent-control was in force in Finland. This was changed in the early 1990s (relaxation of the rent-control, changes in the taxation etc.).

close already in the beginning of 2003, but the zero level was finally breached in the beginning of 2004.

Besides the Finnish data, we could also take a look to the real estate D/Y's in some other countries and examine how well does the ADF-indicator work with their data. A good reference in this respect is Germany, as the developments in the real estate markets in Germany are commonly held as very stable during the last decades and therefore no bubbles should be signalized.

When looking at the bubble indications in the figure 5 we can see that the indicator indicates three periods as bubbles regardless the fact that according to the general acceptance there shouldn't be any. The periods indicated as bubbles according to the adf-coefficient are the periods starting from summer 1978 until the end of 1978, early 1997 as well as the period starting from summer 2003 and lasting until the end of 2003. Other noteworthy features of the indicator are its large volatility and its upward trend.

Concerning the housing policies, 1950s and 1960s favoured rental building in Germany and the renovation programmes since 1970s continued that bias (see for example RICS, 2004). Due to this fact, according to RICS (2004) only 41% of the housing stock is owner occupied and private rental housing constitutes 48% of the housing stock in the West.

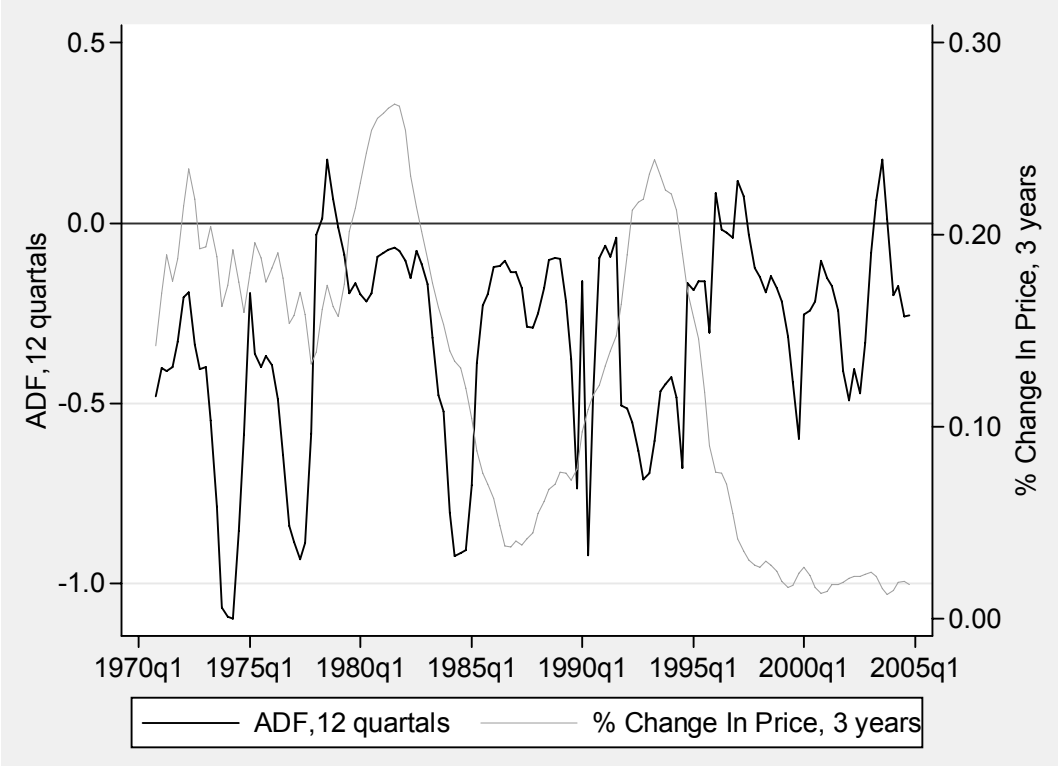
Rents in Germany are regulated in several different levels: there are broad federal rules, regional Länder policies and municipalities with their own specific rules. Rents are usually negotiated freely at the point when households rent the dwellings, but after this contract the rent-controls apply.[21] Strict are also the rules governing the increases that can be placed on rents, meaning that the overall rent levels may lag far behind the current 'true' market rents. This is something that could partly explain why even relatively small price changes could break up the relationship between the rents and prices and signals of bubbles would be reached. At least it could explain some of the observed volatility. Looking at the house price changes in Germany during the period 1975–2004, we could actually spot two periods featured with quicker growth (neither being too dramatic). The first period was experienced during 1978–1981 and the second from 1989-until the end of 1992. The first of these periods matches quite well the period of the bubble-indication, but the second-one is in this sense a bit problematic.

The strong price rise in the late 1980s and early 1990s is related to the substantial increase in housing demand in Germany, while the immigration from east led to sharp rise in the demand of housing in western Germany.[22] This pressure also had an effect to rents: previous peak in rents had been experienced in 1983, but by 1987 the year-on-year increase in rents had reached its lowest

[21] Therefore instead of using information on all rents, we should focus on newly agreed agreements, as only these reflect the prevalent market pressures.
[22] Notice: the German unification.

level during the eighties at 1.6%. By 1993 this level had risen to 6%, to similar levels, which had last been seen in the early seventies. At this time and due to the strong price-rise, the government 'saw fit to foster the construction of new housing by means of a whole series of promotional measures', as mentioned in Deutche Bundesbank's monthly report in January 2002. Maybe this led to the partly excess supply in the German housing markets, which has led the house prices to sunk below their long-run equilibrium level as reported for example by PwC.[23] This could have led to sluggish development in the housing markets during the few last years: as reported in *the Economist* article[24] on April the 20th, the German house prices (the Economist's house price index) moved downwards in 2003 by 1.7% and in 2004 by 1.3% compared to the previous year's values. Perhaps then the final indications of bubbles in the figure 4 could be held as signals of too much downward correction in prices[25] and therefore as signals of negative bubbles.

Figure 4. **Real estate bubble-indications, Germany**



[23] PriceWaterhouseCoopers: European Economic Outlook, June, 2001.
[24] The Economist: Will the Walls Come Falling Down?, 20th of April 2005.
[25] One point in this respect is the quality of the available price information, while it was altered by our own atatistical program to quartal lelvel.

Besides Germany we had the required data for the construction of the indicator available for example from Spain. Since 1976 the average Spanish house prices have risen sixteen-fold in nominal terms and they have doubled in real terms as mentioned by Pages and Maza (2003).

Concerning the developments during the last decade, three rather different periods could after all be separated from the Spanish data. First a period from 1987 to 1991, when the real estate prices experienced an expansionary phase, secondly a period from 1992 until 1997 which was a period with flat growth and finally a period from 1998 to the present day which once again was featured with strong expansionary growth (for example Pages and Maze, 2003). In Spain the year 2003 was the time of the strongest price increases in whole Europe. In the national level prices rose as much as 16% during the second quarter of 2003.

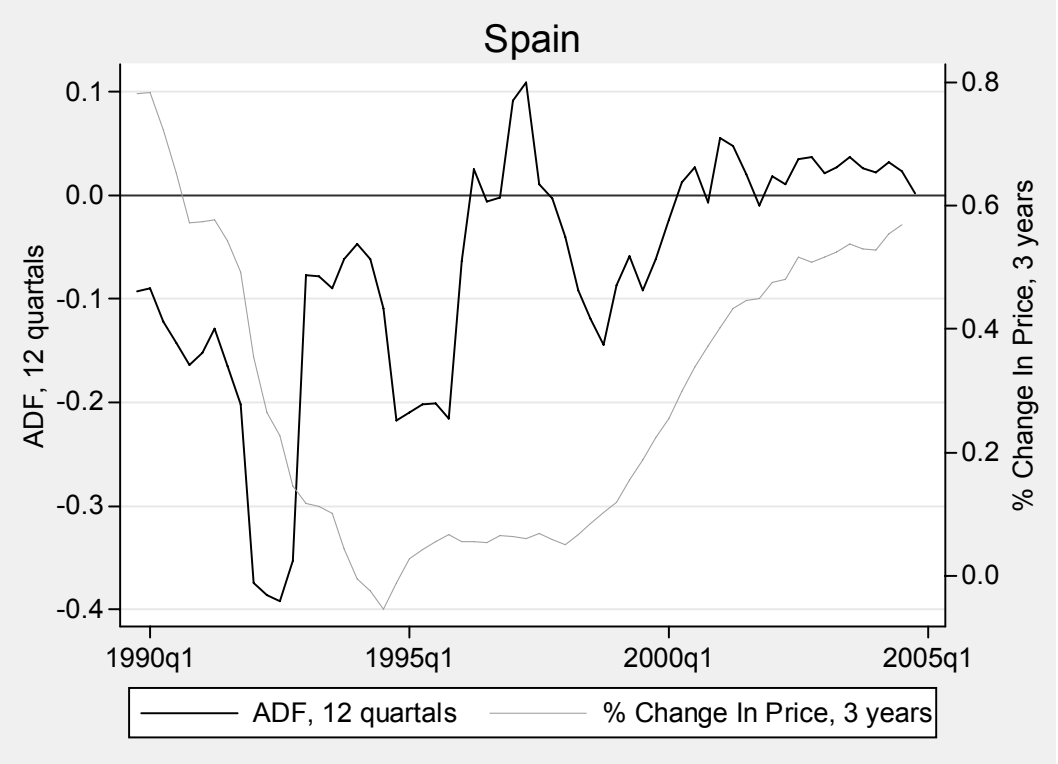
Examining the Spanish rental markets, it can be noticed that most of it is in private hands and only a small amount can be classified as social. Overall the amount of the rentable dwellings is the smallest in the whole Europe: According to RICS (2004) only 15% of housing is rented. The rental markets have been under rent-control, pro-ownership subsidies as well as tax-reliefs, meaning that the true rent increases have been limited to years after mid 1990s, as mentioned also in the RICS's (2004) review. Concerning these developments in rents, it should be pointed out that the indicator-values in our bubble-testing procedure are therefore more reliable only during the last few years.

As was mentioned, two booms can be identified from the Spanish real estate markets during the last decade or so: the first lasted from 1987 until 1991, during which the real house prices rose by over 80% (RICS, 2004). This increase was followed by an economic slowdown during which the house prices fell by 17%. A new economic recovery started in 1998 and together with falling interest rates fuelled a new price rise in the housing markets that even steepened since 1999. Even clearer this steep rise seen in prices has been in Madrid. Concerning the overall developments in the mortgage markets, it is worthwhile to take into account that traditionally mortgages played relatively small role in the Spanish housing market, but during recent years their role have strengthened: since 1990 the outstanding mortgage debt as a percentage of GDP has doubled, being 32% in 2001 (for more, see RICS European household review 2004).

Based on this information, we can reflect the bubble-indications received from the ADF-coefficient in Spain. Indeed, there are two periods signalised as bubbles in the Spanish real estate data as seen in the figure 5: the first period starts around the beginning of the 1997 and lasts until autumn 1997 and the second period starts in the beginning of 2000 and lasts all the way until today. Concerning the indications, especially the last one is easy to explain with the strong price upheaval in the real asset prices in Spain. Also Pages and Maze (2003) conclude their article with notice that there are some evidence of overvaluation during the last few years in the real estate markets. They wrote: 'the

evidence presented points to a current overvaluation of house prices which would, nonetheless, be compatible with trends in the explanatory variables and with dynamic historical pattern of response of prices to those trends.' Their conclusion is that some correction in prices might be expected in the future.

Figure 5. **Real estate bubble-indications, Spain**

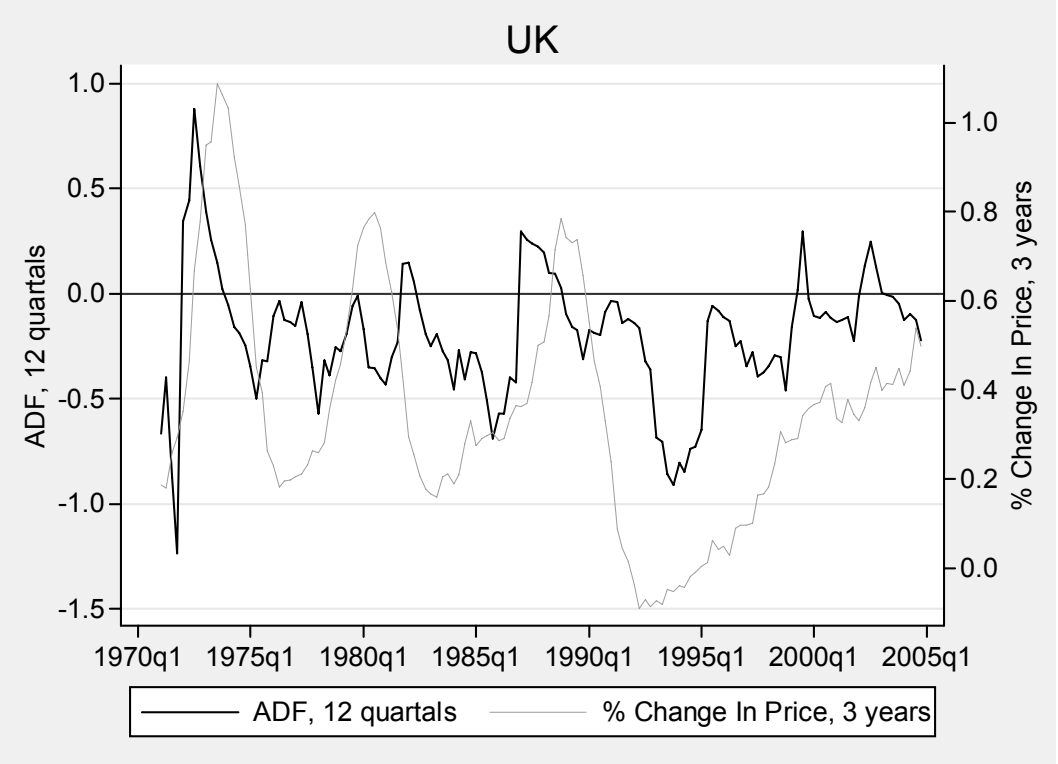


A bit longer data we had available from the UK. The most recent national boom in the house prices was experienced in the UK starting from 1997. Measured annually the house price inflation peaked at 2002, Q3 at 26%. Concerning the earlier booms and busts in the house prices, there can be identified a boom in the 1988–1989, slightly smaller boom/bust in late 1970s/early 1980s and one in the early years of 1970s. Interestingly all of these periods have more or less been identified as bubbles by the adf-coefficient, while it gives the precise indications for the following periods (figure 6): From 1972Q1–1973Q4, 1981Q4–1982Q2, 1987Q1–1988Q4, 1999Q2–1999Q3 and 2002Q2–2003Q1.

Behind the recent price-upheaval one can see several fundamental reasons: during the recent years the economy has been in a strong position. Growth has been over its long-time potential, while unemployment and inflation have stayed low (RICS, 2004). Private consumption has been strong and the amount of mortgage borrowing has boomed. Mortgage markets have been booming due to the low nominal interest rates: indeed, the year 2003 made a new record in the

levels of borrowing. RICS (2004) reports that 'by the autumn of 2003 house price to loan and mortgage income to income ratios for both first-time buyers and moving existing owners were higher than they had been at the peak of the last boom in 1989'. Therefore some researchers have suspected that there could lay a risk that the heavily indebted consumers might under certain circumstances create a negative demand shock to the economy. This remains to be seen.

Figure 6. **Real estate bubbles, UK**



Finally we could take a look at the US housing-markets. In the US earlier larger house price booms were experienced in the late 1970s and late 1980s. The latest boom has been going on since 1995. When looking at the year-over-year percentage changes in the home prices during these three booming periods, the first period resulted approximately 13% real appreciation, the second one a 17% real appreciation and the last one approximately a 36% real appreciation (for example McCarthy-Peach, 2004).

While the US experiences were more thoroughly handled in the section 1.4 and will be handled in section 4, we could take a look to the periods identified as bubbles by the ADF-indicator and find out whether they match the booming periods specified above. The difference between the figures comes through the underlying data: In the first one we have used rent-information from BLS and in the second one we are using the OECD's CPI component information.

The periods which are identified as being bubbles are much the same in both of these figures: the first period starts at the end of 1986 and lasts until the autumn 1987, the second period is in the beginning of the year 1995 and the third period starts in the autumn 1998 lasting until the end of 2001 and reappearing again in the autumn 2003, just to continue all the way until present. It seems that compared to the market developments the timing of bubble-signals matches well the periods when there has been a strong arise in the house prices (see figures 7 and 8).

Figure 7. **Real estate bubbles, USA (BLS&OFHEO)**

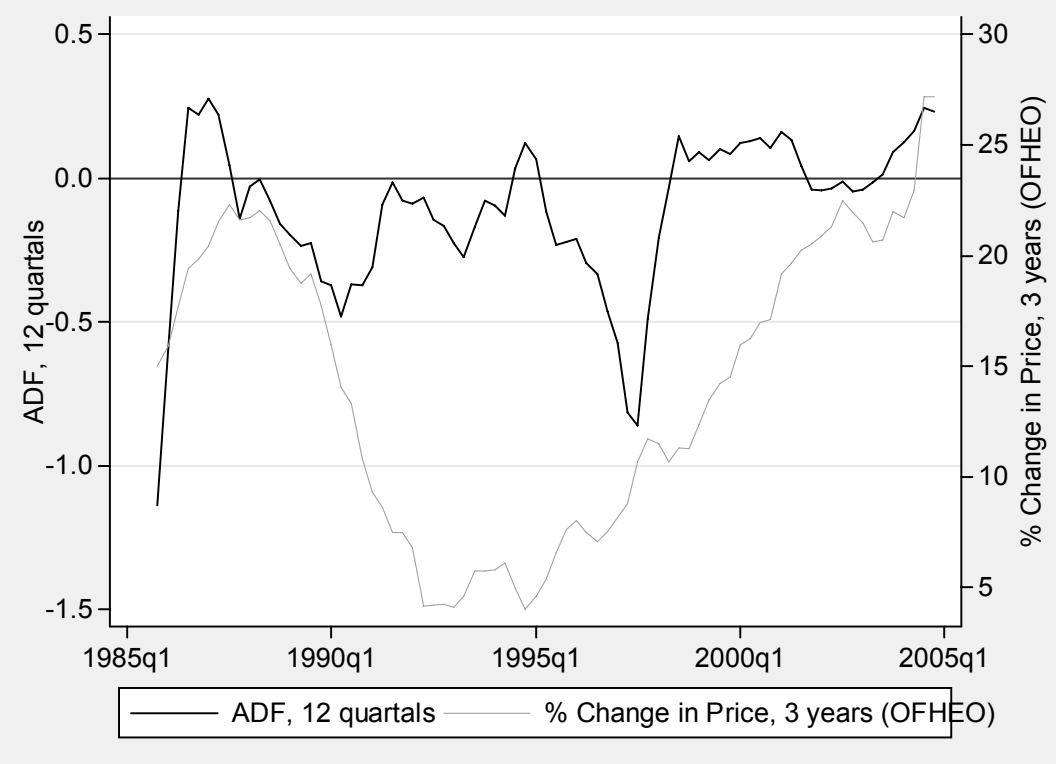
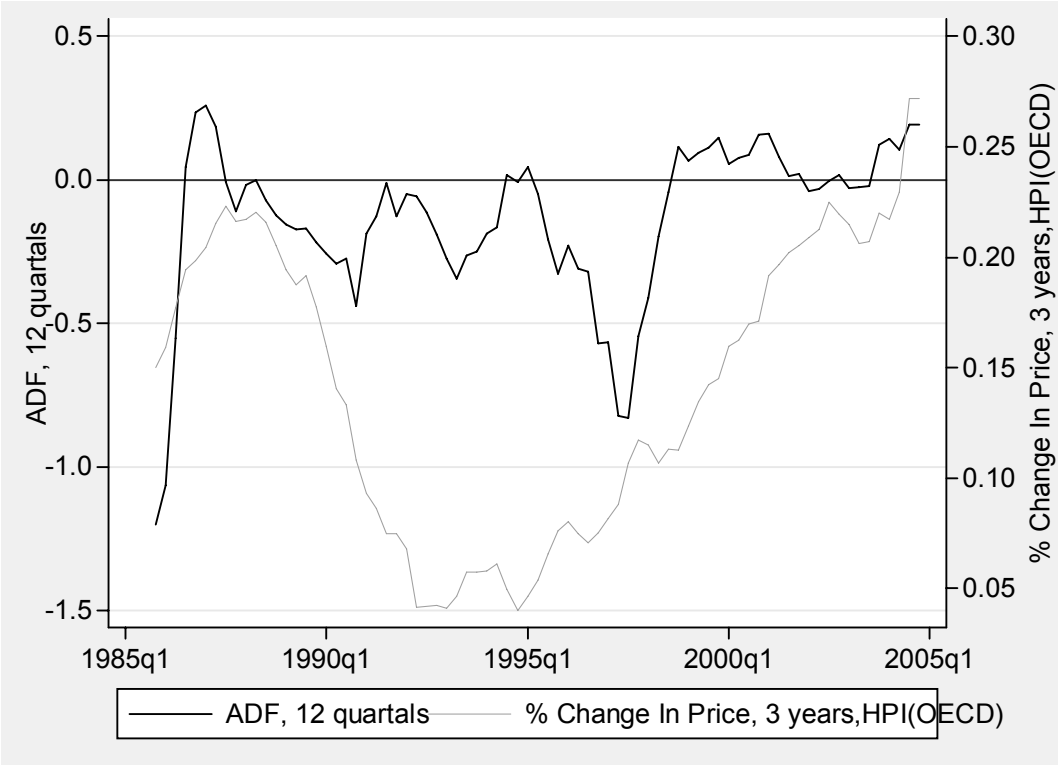


Figure 8. **Real estate bubble-indications, USA(OECD&OFHEO)**



4.2 Regional developments in the US housing markets

Instead of using only country-level data it seemed worthwhile to examine this method more thoroughly with regional data, while with regional data it could easily be tested if the method would be able to separate between region-specific developments.

Good regional data for this purpose was quite hard to find. The longest data was found from the US. The geographical areas in the US were chosen so that they would represent different parts of the country: a bit problematic was that there were no such series available which would leave all metropoles outside. This could have helped in testing the ADF-methodology, while we could have used truly rural area rent and price-series as a reference (with an expectation that there are no bubbles in the rural areas).

First we should try out the basic unit root tests. In several recent pieces of literature the panel-based unit root tests have been emphasized to have a higher power than unit root tests based on individual series.[26] Due to this we first

[26] Concerning the panel unit root tests, see for example Breitung (2000); Im, Pesaran and Shin (2003); Hadri (2000); Levin, Lin and Chu (2002) etc.

performed pooled unit root tests to the local-level US data consisting of the following 6 areas: Los Angeles (incl. Riverside and Orange County), San Francisco (incl. Oakland and San Jose), New York (incl. New Jersey-Long Island), Boston (incl. Brocton and Nashua), Cleveland-Akron as well as Chicago (incl. Gary and Kenosha). As remembered from the section 3, the existence of unit root in the log dividend yield was held to be consistent with rational bubbles in asset prices.

The area level data was collected from two sources: The rent data at area level was gathered from BLS at quartal frequency[27] and the price-data was collected from OFHEO's database.[28] We confronted some troubles with the price-data, since the areas did not correspond directly to those reported by BLS. Problem was solved through using the metropolitan statistical area grouping: we combined the area price information, weighting it with the amount of inhabitants and combining the weighted price-information into larger groups in order to get the areas to correspond to those reported by BLS.

The results of the pooled unit root tests are reported in the following table (table 4). The data covers period from 1984Q1 until 2005Q1. There are 6 cross-sections and the total amount of observations is 474. We performed the tests with varying assumptions concerning the regressors: first we did the tests without regressors as well as with individual intercepts and finally combined the individual intercepts with individual trends. As seen from results, the choice between these produces large differences in results. When looking at the graphs of the log dividend yields, the best option would be to include the individual intercepts into the tests. As a lag selection method we have used either Schwarz information criteria or the Akaike information criteria and Newey-West using Bartlett kernel for the bandwidth selection.

[27] www.bls.gov. The rent-information is part of the CPI-data series and can be downloaded from the web-pages.
[28] www.ofheo.gov.

Table 4. **Pooled unit root tests for the regional US data**

Unit root test	Method	Statistic	Prob.	Result
Exogen. variables: None	Common unit root: Levin, Lin & Chu	-4.755	0.000	Rejection of unit root
	Breitung	1.310	0.904	No rejection, common unit root process
	Hadri[a]	–	–	–
Lags: SIC, 0 to 3	Individual unit root: Augmented Dickey-Fuller	36.831	0.000	Rejection of unit root
	Phillips-Perron	58.163	0.000	Rejection of unit root
	Im, Pesaran & Shin	–	–	–
Exogen. variables: None	Common unit root: Levin, Lin & Chu	-4.615	0.000	Rejection of unit root
	Breitung	0.445	0.672	No rejection, common unit root process
	Hadri	–	–	–
Lags: AIC, 1 to 4	Individual unit root: Augmented Dickey-Fuller	36.973	0.000	Rejection of unit root
	Phillips-Perron	58.163	0.000	Rejection of unit root
	Im, Pesaran & Shin	–	–	–
Exogen. variables: Individual effects	Common unit root: Levin, Lin & Chu	1.675	0.953	No rejection, common unit root process
	Breitung	-2.552	0.005	Rejection of unit root
	Hadri	5.698	0.000	Rejection, common unit root process
Lags: SIC, 0 to 3	Individual unit root: Augmented Dickey-Fuller	4.841	0.963	No rejection, individual unit root process
	Phillips-Perron	2.490	0.998	No rejection, individual unit root process
	Im, Pesaran & Shin	2.812	0.997	No rejection, individual unit root process
Exogen. variables: Individual effects	Common unit root: Levin, Lin & Chu	0.530	0.702	No rejection, common unit root process
	Breitung	-2.451	0.007	Rejection, no unit root
	Hadri	5.698	0.000	Rejection, common unit root process
Lags: AIC, 1 to 4	Individual unit root: Augmented Dickey-Fuller	5.773	0.927	No rejection, individual unit root process
	Phillips-Perron	2.490	0.998	No rejection, individual unit root process
	Im, Pesaran & Shin	1.512	0.934	No rejection, individual unit root process

Unit root test	Method	Statistic	Prob.	Result
Exogen. variables: Individual effects, individual trends	Common unit root: Levin, Lin & Chu	0.801	0.788	No rejection, common unit root in process
	Breitung	-1.896	0.028	Rejection, no common unit root
	Hadri	7.954	0.000	Rejection, common unit root process
Lags: SIC, 0 to 4	Individual unit root: Augmented Dickey-Fuller	6.113	0.910	No rejection, individual unit root in process
	Phillips-Perron	3.917	0.984	No rejection, individual unit root in process
	Im, Pesaran & Shin	2.467	0.993	No rejection, individual unit root in process
Exogen. variables: Individual effects, individual trends	Common unit root: Levin, Lin & Chu	0.330	0.629	No rejection, common unit root in process
	Breitung	-1.491	0.067	No rejection, common unit root in process
	Hadri	7.954	0.000	Rejection, common unit root in process
Lags: AIC, 0 to 4	Individual unit root: Augmented Dickey-Fuller	6.863	0.866	No rejection, individual unit root process
	Phillips-Perron	3.917	0.984	No rejection, individual unit root process
	Im, Pesaran & Shin	1.681	0.953	No rejection, individual unit root process

[a] It must be noticed that the Null hypothesis in Hadri is that there is no unit root in the process, while in all other tests the null is that there is a unit root in the process.

As these results show, the outcome is very sensitive to the assumption concerning the exogenous variables: if we assume that there are no exogenous variables, we can in nearly every case reject the existence of a unit root in the process. On the other hand when we include either individual effects or trends to the tests we can in most of the cases conclude that there is a unit root in the process. As mentioned, the unit root in the log dividend yield can be held to be consistent with the existence of rational bubbles in asset prices, meaning therefore that during the periods in focus (1984Q1–2005Q1) there are bubble/bubbles in the regional house prices series in the US.

In addition to the unit root tests we counted the ADF-indications for the regional data using the 12 quarters rolling window. According to the indications given by the ADF-indicator we can observe bubbles in each of these regions during the time-periods in focus. One striking character in the indications is that we can spot nearly coexistent bubble-indications in each of these regions during two periods: 1987–1989 and during 2000–2005Q1. In addition to these there are

some special regional bubbles in each case. Next we can take a look to these more precise indications by examining figures 9 to 21.

Figures 9 and 10 present the developments in the Los Angeles region during period 1984Q1–2005Q1. In figure 9 we can see the overall development of the housing price index and its change over one year. There are clearly two periods characterised by strong growth: period covering years 1987–1989 and a period starting from 1995. In figure 10 we have the ADF-coefficent indications for the bubble periods. When we held the 0-level as a reference value for critical level, it is crossed three times: 1987Q3–1989Q3, 1993Q3–1994Q4 and 2001Q4–2005Q1. The first and third of these indications are clearly related to the strong rises in the price-level, but the midst-one is rather related to the strong downward correction. This could be interpreted to mean that the house prices have corrected too strongly compared to the rental flow (it must be noticed though that usually rents react with a lag to the price-level movements).

Figure 9. **House prices in Los Angeles**

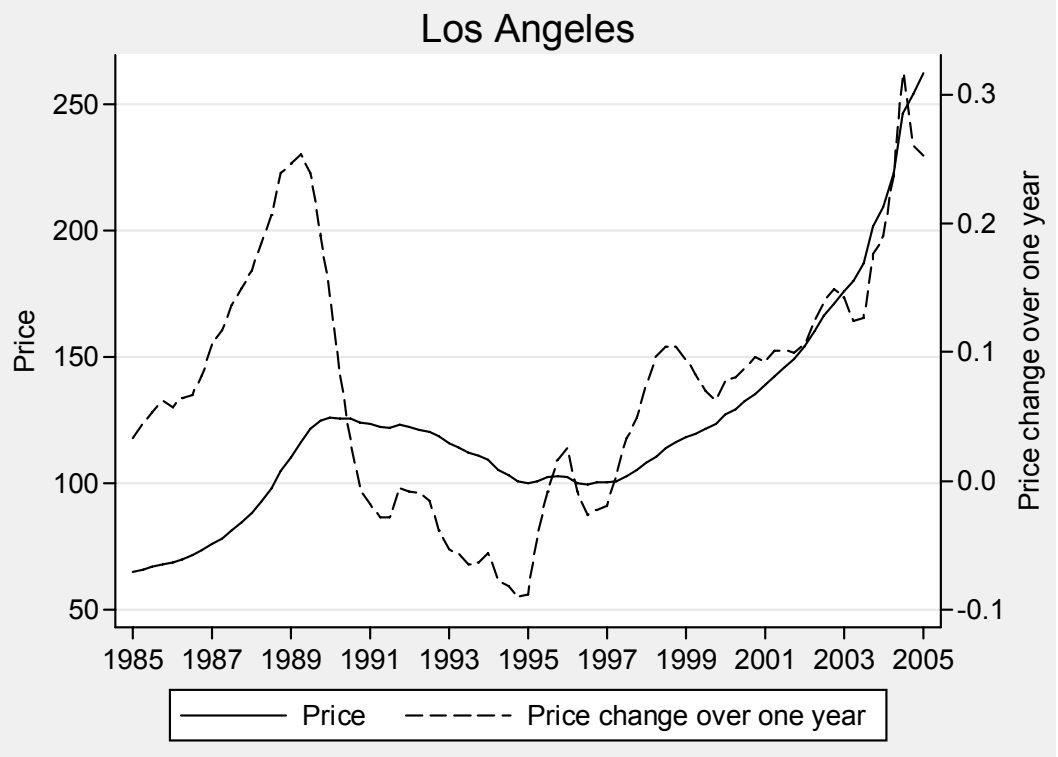
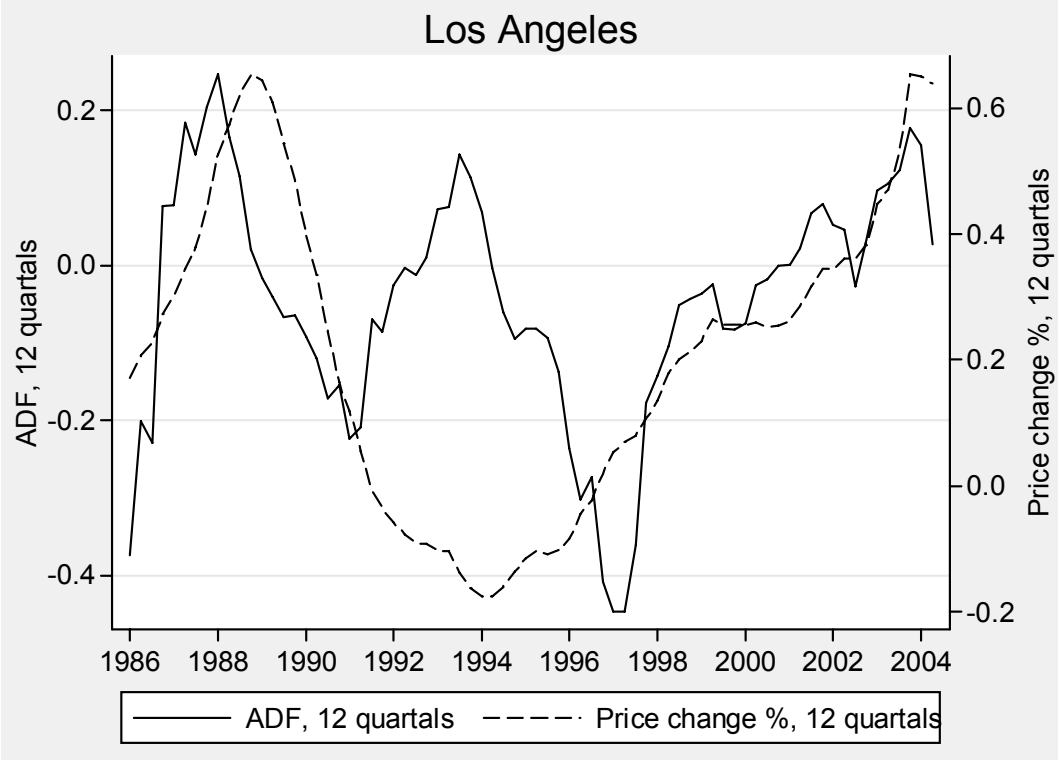


Figure 10. **Real estate bubble-indications, Los Angeles**



In figures 11 and 12 we can see the congruent developments in San Francisco. As can be observed from the figure 11, the timing of the strong arises in the prices is quite the same as it was in Los Angeles, the difference being the much more moderate rate of growth during period 2002–2003. Concerning the bubble-indications given by the ADF-coefficient values, there are more differences between these two cities. As the San Francisco data cover a bit shorter period (from 1987Q1 until 2005Q1) the first bubble indications are given right in the beginning of the figure related to the 1987–1989 price arise. The second indication covers period 1994Q2–1994Q4 and this period is clearly related to the downward correction in the price index. The last two indications are received during 1999Q2–2000Q3 and 2003Q4–2005Q1. These periods are once again related to strong growth rate in the house price index.

Figure 11. **House prices in San Francisco**

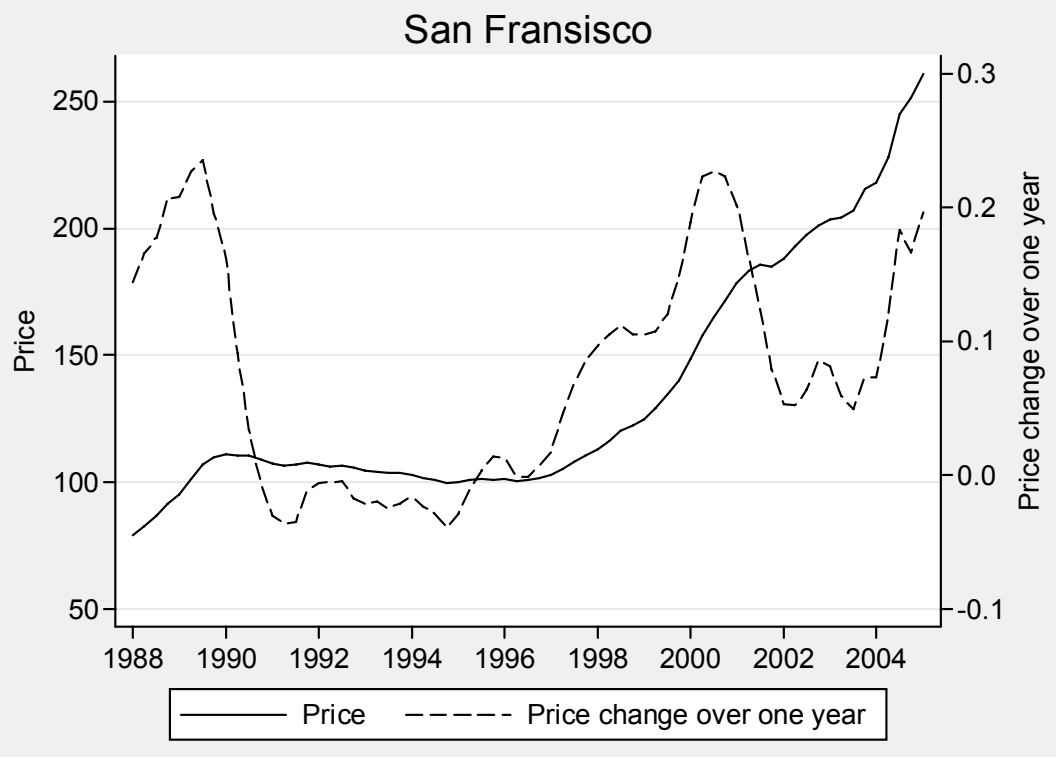
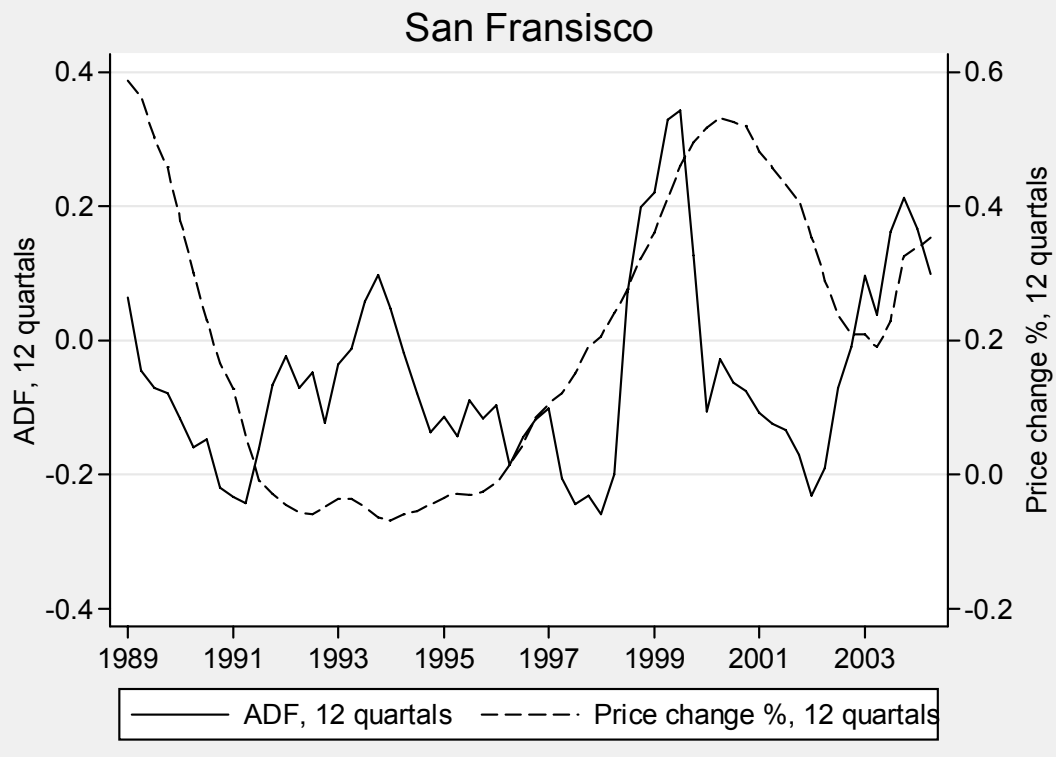


Figure 12. **Real estate bubble-indications, San Francisco**



Concerning the developments in other large metropolis in the US we could take a look at the east coast cities New York and Boston. In figures 13 and 14 we present the developments in New York and in figures 15 and 16 we present the developments in Boston. Compared to the Los Angeles and San Francisco figures, the developments in the price indexes resemble them most in New York (figure 13). In Boston the developments are slightly differently shaped: the continuous upward growth starts already in 1991 (figure 15). Concerning the bubble indications given by the ADF-coefficient, the Boston periods are shown in figure 16 and New York periods in figure 14. In Boston the indications are for following periods: 1990Q2–1991Q2, 1998Q3–2000Q4 and 2003Q4–2005Q1 and in New York for 1986Q4–1987Q3, 1990Q2–1991Q3, 1994Q3–1995Q1 and during a rather long period reaching from 1999Q3 until 2005Q1. In New York the first and last periods are strongly related to the price index arises and the second bubble indication is related to downward revision in the prices. The possible cause for the third indication during 1994–1995 is less clear, but the overall indication itself is also very short.

Figure 13. **House prices in New York**

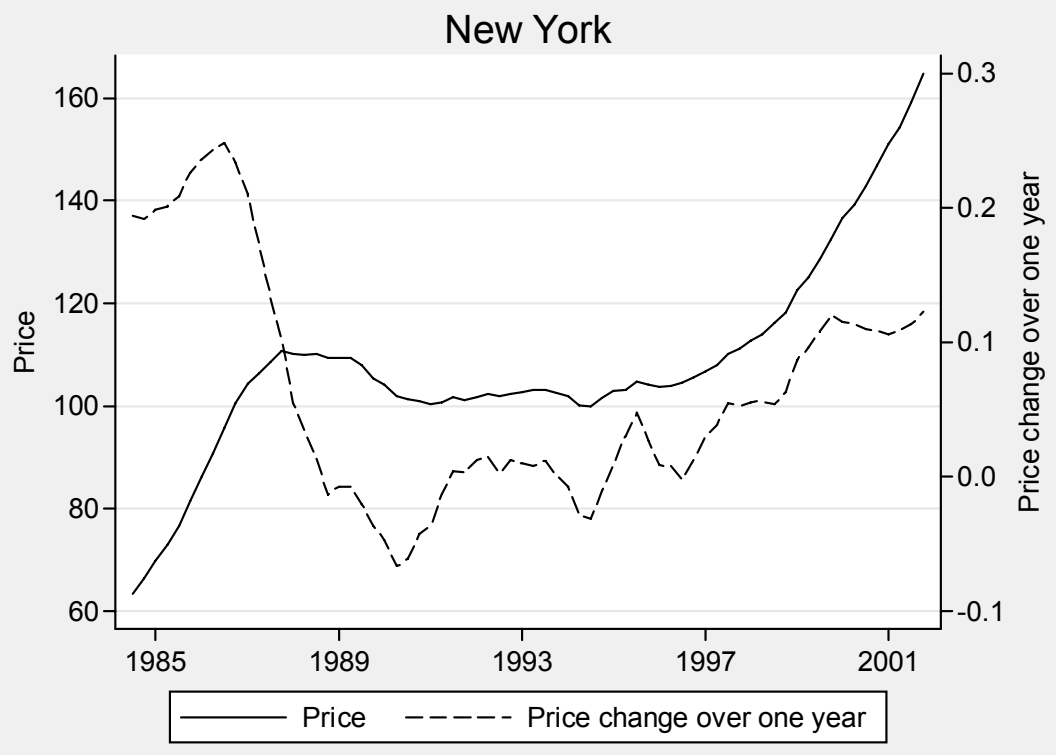


Figure 14. **Real estate bubble-indications, New York**

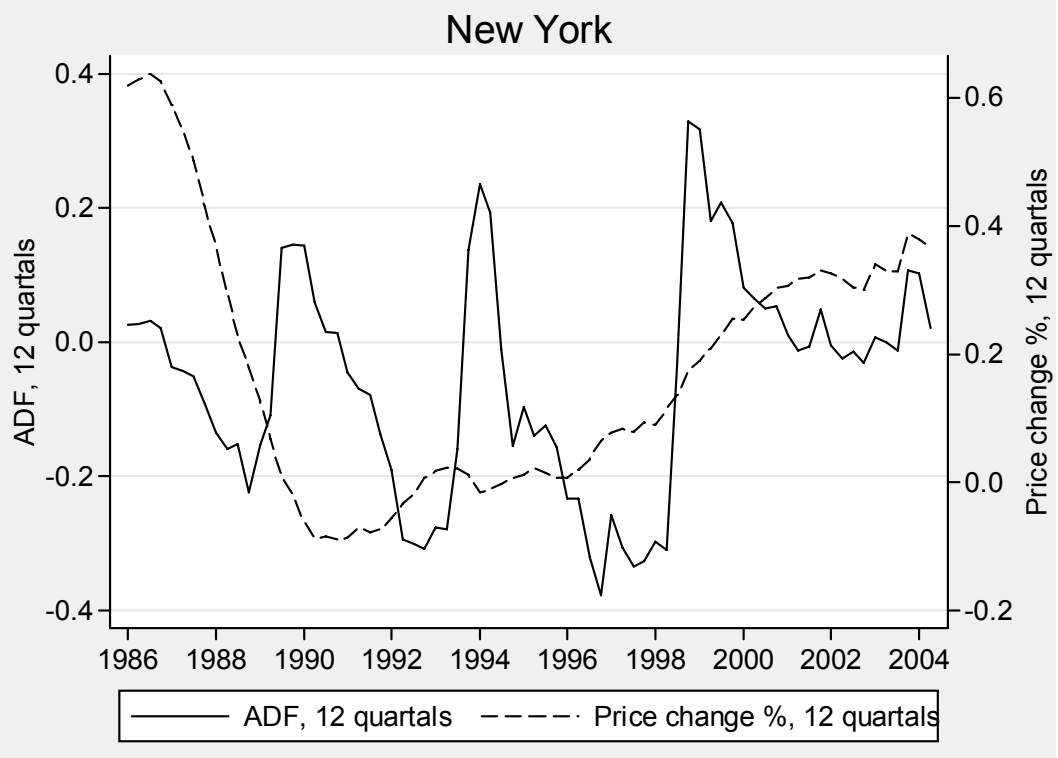


Figure 15. **House prices in Boston**

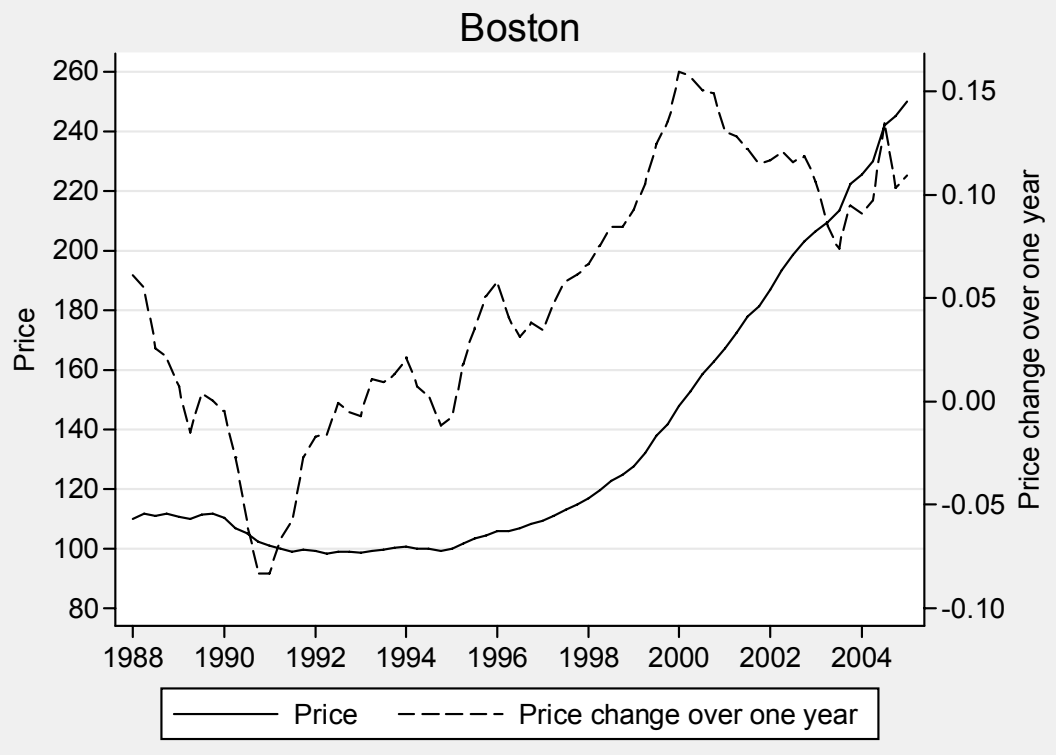
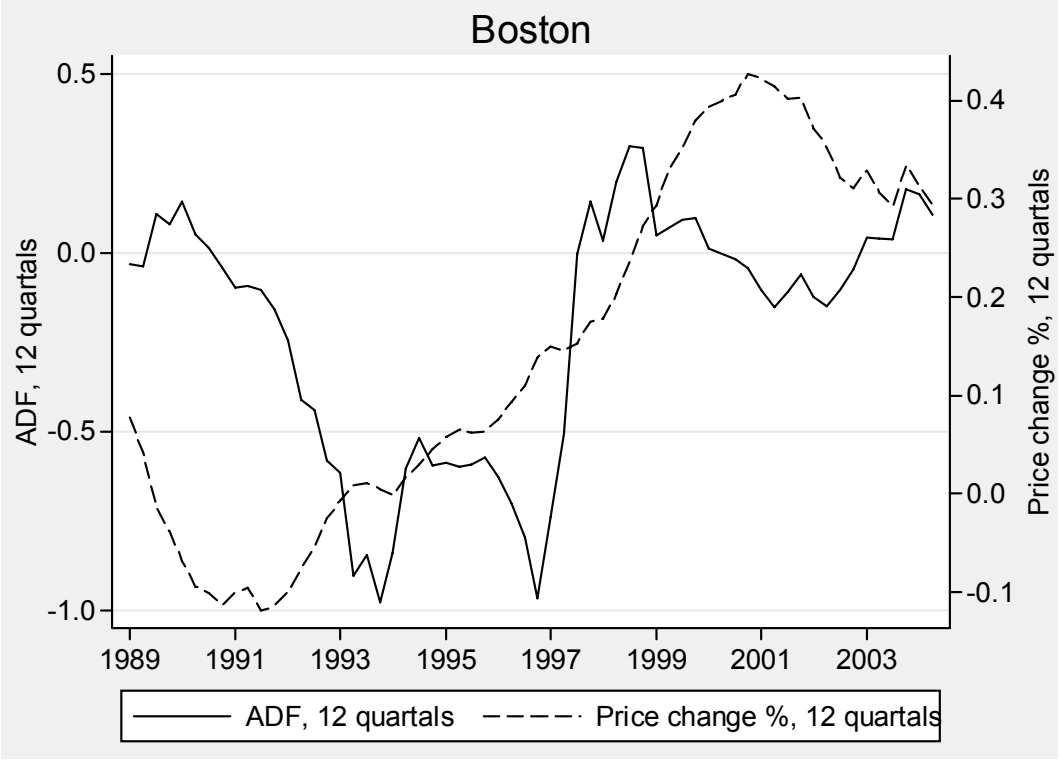


Figure 16. **Real estate bubble-indications, Boston**



As a last point we could take a look to two innerland regions and their housing price developments. These two regions are the Cleveland-Akron area as well as the Chicago-Kenosha area. When looking at the overall price developments in the figures 17 and 19, we can immediately notice that the level of the overall arise in the index has been much more modest that for example in Los Angeles. Concerning the Cleveland-Akron figure (figure 17) it is interesting to see that the price change over a year seems to be downward trending over the period in focus. In the Chicago-Kenosha figure (figure 19) we can spot two clear arises in the yearly price changes: in 1986–1987 and a period starting from 1997. Concerning the bubble-indications, for the Cleveland-Akron area the periods are following: 1989Q4–1990Q3, 1993Q4–1994Q3 and 2004Q3–2005Q1 (figure 18) and for the Chicago-Kenosha area 1987Q2–1988Q3 and at time to time during period 2000Q2–2005Q1 (figure 20).

Figure 17. **House prices in Cleveland-Akron**

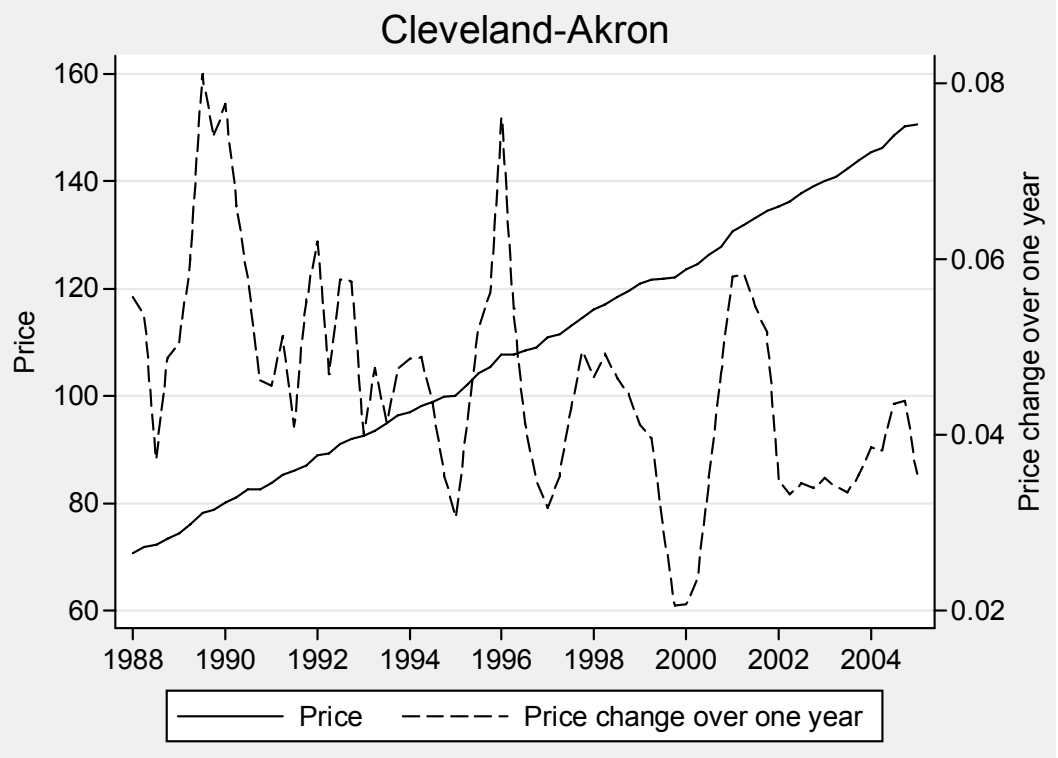


Figure 18. **Real estate bubble-indications, Cleveland-Akron**

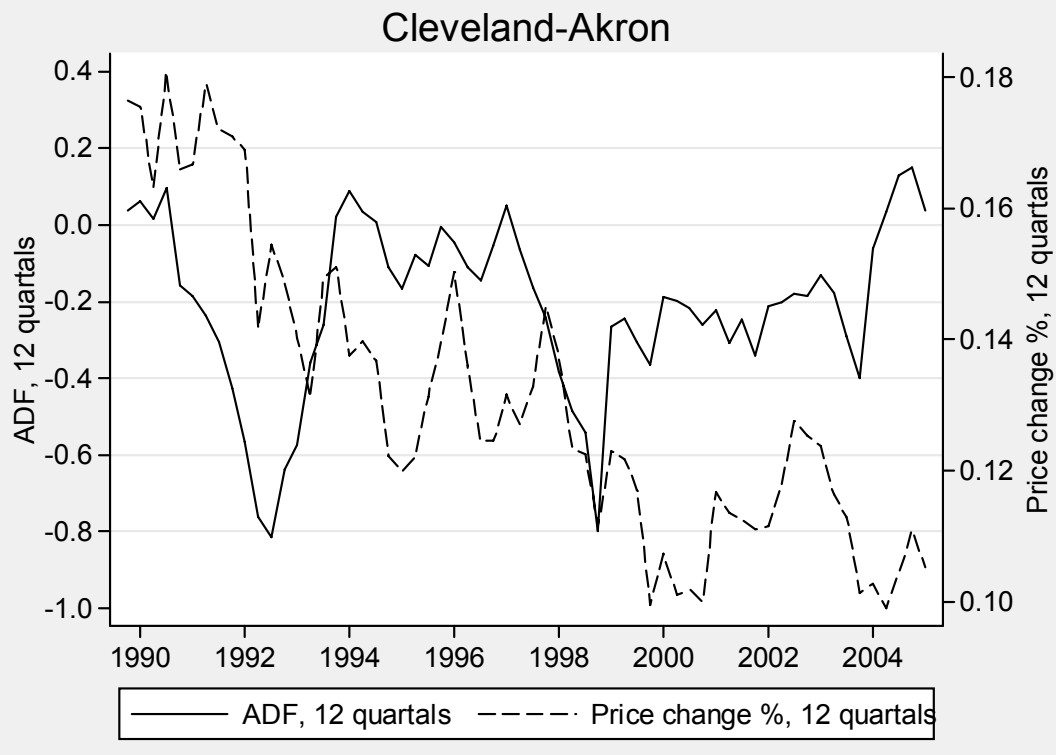


Figure 19. **House prices in Chicago-Kenosha**

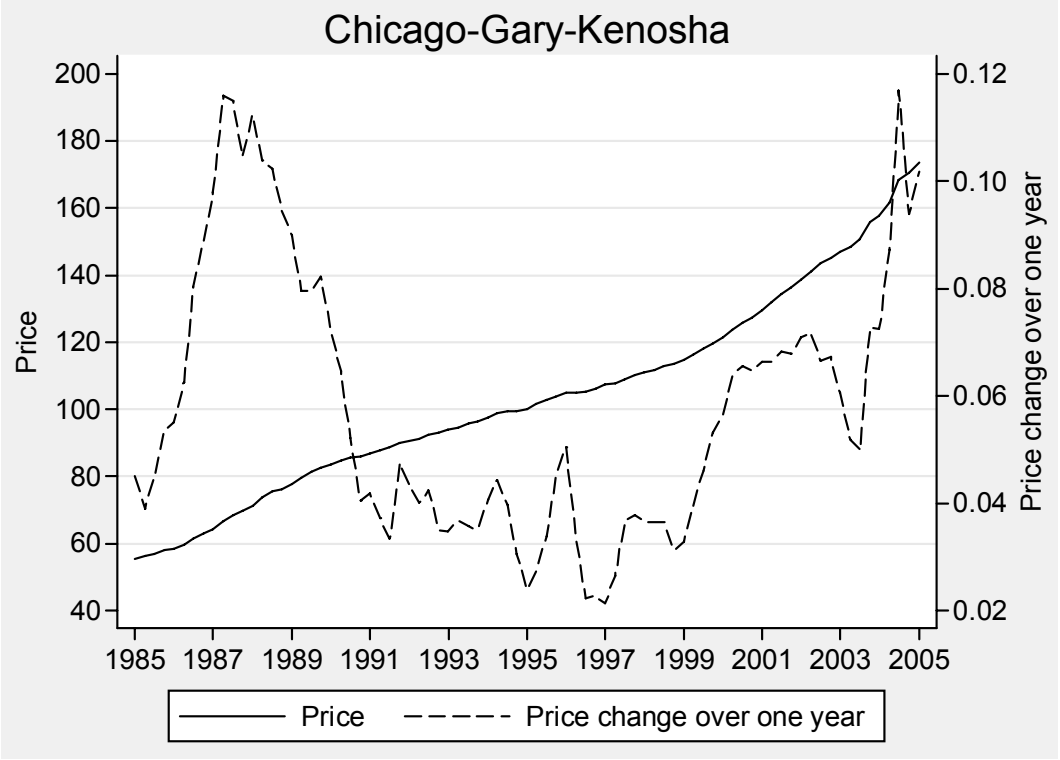
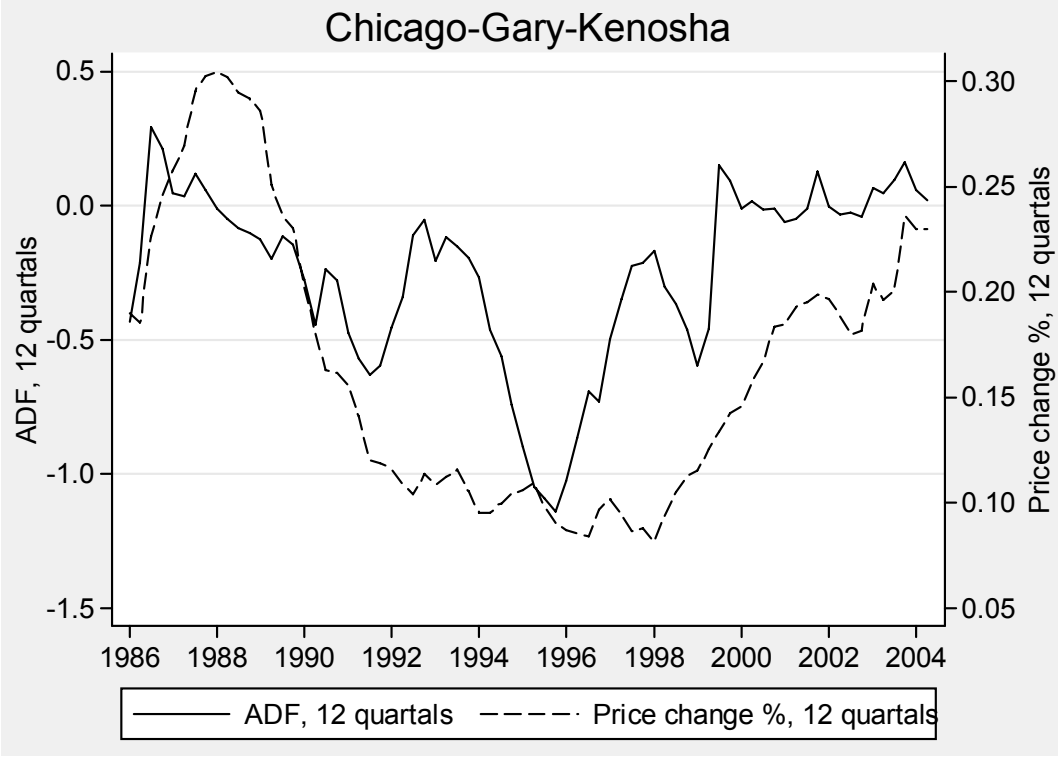


Figure 20. **Real estate bubble-indications, Chicago-Kenosha**



Next these bubble-indications given by the ADF-indicator concerning the regional US housing markets can be compared to the bubble-results reported in the earlier articles. During the last 25 years there has been at least 2 housing price cycles in the US as reported for example by Dreiman (2001). According to her report the real house prices peaked in the US in 1979, followed by a 3-year decline which ended in 1982. Between 1983 and 1989 the prices rose again, approximately by 19%, but then the beginning of the 1990s witnessed once again rather strong decline in prices between years 1989 and 1995. Starting from 1995 the prices have been appreciating and the first articles concerning bubbles in the US house prices started to appear in the beginning of 2000s.

Case and Shiller (2003) described in their research the developments in the several cities during the end of the 1980s as well as during early 2000s, giving therefore an excellent reference. According to them the first booms in the Los Angeles[29] and San Francisco were quite similar: prices in both metropolitan areas peaked in the second quarter of 1990 (in nominal terms 125%). When compared to the bubble indications given by the ADF-coefficient, the periods match somewhat. The point is that the ADF-indications end before the second quarter of 1990: in Los Angeles the last bubble-indication is given during 1989Q3 and in San Francisco at 1990Q1. Concerning the bust following the strong boom, Case and Shiller (2003) reported it to have been the most severe and longest lived in Los Angeles as the prices sunk 40% in real terms (29% in nominal), recovering only since 1996. In San Francisco the prices dropped less, only by 20% (14% in nominal) and they started to recover earlier, already in the beginning of 1993. The story in Boston was a bit different: The prices peaked earlier than for example in California. According to Case and Shiller (2003) the house prices in Boston started to rise rapidly in 1984 and in 1985 they went up by 39%. By the time the prices topped in 1988 they had gone up by 140 per cent. Problem concerning this period is that our data begins rather late, making us to be able to catch only the strong downward correction in the prices in the early 1990s. Concerning the data from Chicago the first indications can be reached through Case's and Shiller's (1987) earlier research where they constructed a quarterly existing home price index for period 1970–1986. The real prices in Chicago rose at fastest rate in the end of 1977 during period 1970–1986, but the rate was nothing compared to that experiences for example in San Francisco by that time.

During period 1993–1998 the real cumulative house price appreciation was 6% as mentioned in the OFHEO 1998Q4 -report. There were large regional differences though: the Pacific and Middle Atlantic Divisions experienced total house appreciation below the rate of general inflation in their regions. In the Pacific Division (Alaska, California, Hawaii, Oregon, Washington) the house

[29] It must be noted that the regional definitions may not be completely similar in our research compared to those used in Case and Shiller (2003).

prices were declining in 1993 as well as in 1994 and the appreciation began only in early 1995. The Middle Atlantic Division (New York, New Jersey, Pennysylvania) on the other hand experienced a real 3% cumulative house price depreciation during the period 1994–1996.

Since Q2 in 1999 the house prices have been increasing over 5% annually in the US and for last four quartals the appreciation have been over 10%, being 12.5 between 2004Q1–2005Q1. Especially fast the prices have arisen during the last five years in California (103% in nominal prices), Rhode Island (97%), DC (108%), Hawaiji (83%) and Nevada (83%) (OFHEO, 2005). McCarthy and Peach (2004) reported a slightly different list (period 1999–2003), while they reported largest house price rises to have taken place in California, Massachusetts, New Hampshire, New York, New Jersey and Washington DC. The lowest price rises over the last five years have taken place at the state level in Indiana, Texas, Utah, Nebraska and Mississippi. Among the 20 bottom metropolitan areas at the five year performance period is also Cleveland-Akron area: the price arise over a five year period has been only about 20%, being only approx. 3.5% last year.

Concerning the more volatile prices in some areas, McCarthy and Peach (2004) came into a conclusion that especially the changing demand fundamentals should cause the prices to fluctuate more in California and northeast, while in these areas the price appreciation is a consequence of improved economic conditions combined with relatively unresponsive supply. The point here is well appreciated: this could be true for all areas in the short run, while the construction of new houses is somewhat restricted in the short-run. This could lead to increasing house-prices whenever the demand of houses would increase. At easiest this will happen when the low interest rate environment is combined with strong belief of consumers on their own economy. To look more thoroughly these relationships and their contribution to bubbling real estate prices will be the focus of our next research.

Concerning the construction, the current housing boom has lasted for 13 consecutive years in the US: by comparison, the next-longest expansion since 1970 without significant drops lasted just five years as reported by the Joint Center for Housing Studies of Harvard University in their latest Nation's Housing report. At present this has caused the homeownership to post all-time high figures at 69% when households of all ages, races and ethnics seem to join the home-buying boom.

5 Conclusions

Many recent articles have discussed the possibility of bubbles in the housing prices at present. An important point is that this discussion is not focused on some restricted areas but seems to be a truly global phenomenon. Therefore important questions arise, among which the following: if we are in the bubble, is it going to burst and what will be the worst consequences from it.

It is true that the housing prices have risen quickly in the past years after the stock market bubble. Reasons for the quick rise are several: partly this might be because of resource allocation from stocks to real estates, but mainly this effect has come because of internationally low interest rates which have increased the demand in the housing markets. It seems that in many countries home prices have risen much more in real terms since 1997 than during any previous boom. The Economist (June 18th – 24th, 2005) reported that this current arise in the house prices seems to be the biggest bubble in history, being even bigger than the end of the 1990s stock market bubble. The threat of being currently in a danger of bubbling prices phase was backed also by our various unit-root tests: by unit root as well as by ADF-indicator tests which we performed in the country-level as well as for the regional level in the US, although due to the caveats these results should be interpreted with caution.

Even though our new indicator was able to give us quarterly and quite well working indications of bubbles, it must be noticed that there are still some serious caveats in it. The way it is constructed relies heavily on the present value pricing formula and on assumption that we can parallel rent flow with dividend flow in order it to function as required we would need 'freely' market-determined rent-flow, which is quite a young phenomenon. In this research we also operate with the 'raw'-data which does not take into account the interest- or tax impacts and this could bias the results from the bubble-tests. A further point still is that the accuracy of the housing- and rental indices are heavily criticised in many instances. Maybe in the future enough data will be available in order to be able to try out these estimations with larger frequency and with pure rent-data. And an additional problem still is the assumption concerning the distribution of the residuals, while they are not normal in most of these cases, meaning that instead of the 0-limit for the bubble indications, we should define the critical levels that would be in line with the underlying distribution of the residuals.

Even though there are several caveats still to be worked out, the purpose of this research was to provide a one additional point of view to the bubble-testing and judgement of the developments in the housing markets. The method provides a new point of view to the subject and is therefore highly experimental, but the results seem to give encouraging results in the US for a longer period, but also in Europe at least since the mid 1990s when the rent-control in most of the countries

loosened. Encouraging in a respect, that they indicate pricing-failures, ie bubbles, during periods which are documented to be the periods of large price reactions in the real estate markets.

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Appendix 1

Rent control

The purpose of the rent-control was to quarantee an affordable accommodation to everyone, to avoid segregation, to redress the landlord-tenant negotiation power and to limit rent volatility as mentioned in ECB's (2003) report, but it created some problems as well. The changes in the rent level appeared to be stiff, especially difficult being the revisions of existing rent-contracts. Therefore it is noticed in the ECB's report that 'rents on the new contracts may reflect more closely the tightness in the housing market and housing prices, although regulations may again set limits on how much rents in new contracts can deviate from those in existing contracts.' Due to the fact that the rent-control system has been seen as a source to mis-functioning and shrinking of the rental sector, many of the EU countries have revised the systems during the last decade. Basically the rent-control can come through three fields, namely either through regulations governing how the rents will change during the rental period, regulations concerning the new rental contracts or through regulations concerning the contract termination. Lately, as mentioned in the ECB's (2003) report, many of the EU countries have moved towards a system where some rent indexation is allowed. The major regulatory changes concerning the rents can be seen from the following table (table 1):

Table A1.1 **Major reforms of rent regulations since 1980**

Belgium	1984: Rent increases linked to CPI. 1985–1987: Indexation temporarily suspended. 1991: Freely negotiated new rental fixed term contracts introduced. 1997: Limits set to new short-term agreements.
Denmark	1990: Condominiums built after 1991 exempt from rent control.
Germany	1983: Introduction of upper limit of 30% in a three-year period on rent increases for sitting tenants; rent escalation clauses and rent contracts linked to a price index permitted. 2001: Upper limit on rent increases in a three-year period reduced to 20%. Period of giving notice for tenants reduced to three months.
Greece	1997: Freely negotiated rents in new contracts. Minimum duration of contracts of three years.
Spain	1985: Freely negotiated rents in new agreements. 1995: Minimum lease of five years (at tenant's option); CPI indexation. One-off updating of existing contracts (to be implemented over ten years).
France	1997: New contracts liberalised.
Ireland	No significant controls/regulations on rent contracts.
Italy	1992: Freely negotiated new fixed-term contracts introduced. 1998: Two types of 'free' contracts: freely negotiated at the individual level at the start and contracts where yearly rent increases are collectively negotiated by landlords and tenants.
Luxembourg	1987: Increases in the rents of dwellings built before 10 September 1944 and clarification of the meaning of invested capital for those built after this date.
Netherlands	1994: Liberalised more expensive segment of rental markets.
Austria	1986: Partial liberalisation of new tenancies. 1994: 'Indicative value rent system' introduced.
Portugal	1981: Freely negotiated rent contracts for new tenancies introduced (but no indexation allowed in these contracts). 1985: Mechanism of updating all rents with CPI; one-off updating of old contracts (but still remaining very distant to rents in new contracts). 1990: Possibility of setting a limit on the duration of rental contracts. 1993: Possibility of introducing different indexation mechanisms under specific circumstances.
Finland	1990–1995: Gradual liberalisation of rent controls. After 1995: rents are practically free from public control; they should not be 'excessive' (in a legal sense).
Sweden	No major reforms that could improve the efficiency of allocation in the rental sector have been undertaken.
UK	1988: Assured tenancy – eviction easier and initial rent and indexation negotiated.

Source: ECB's report on structural factors in the EU housing markets, 2003.

Appendix 2

Distributions

Figure A2.1 **Theoretical Quantile-Quantile, Finland (12Q)**

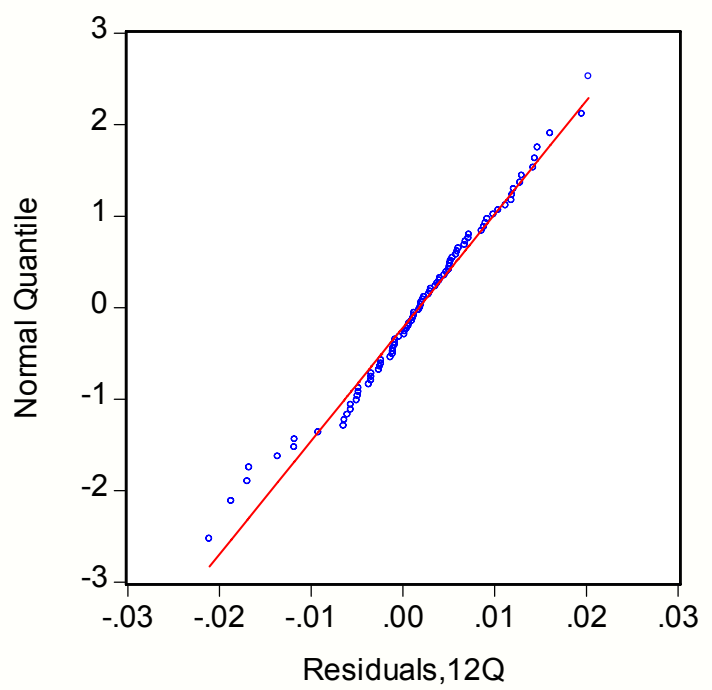


Figure A2.2 **Kernel density, Finland (12Q)**

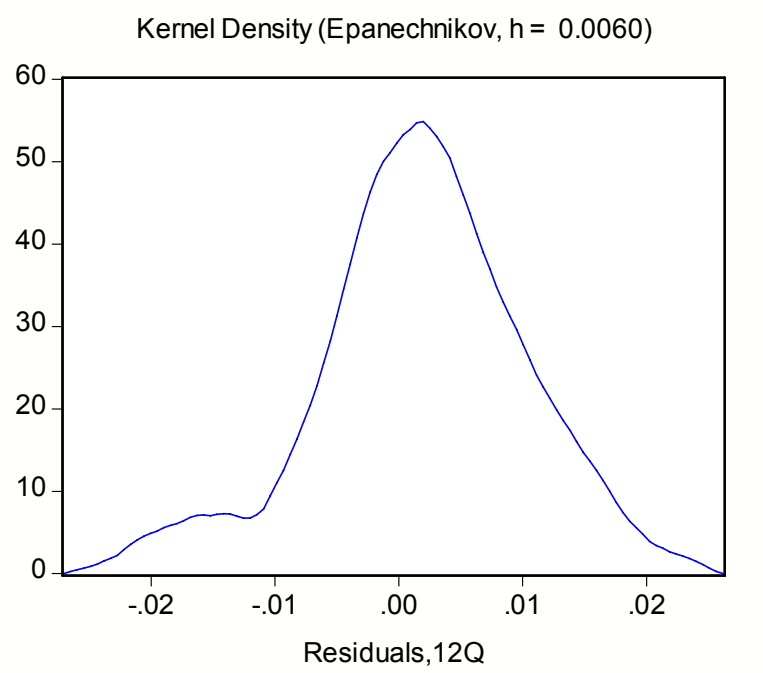


Figure A2.3 **Theoretical Quantile-Quantile, Spain (12Q)**

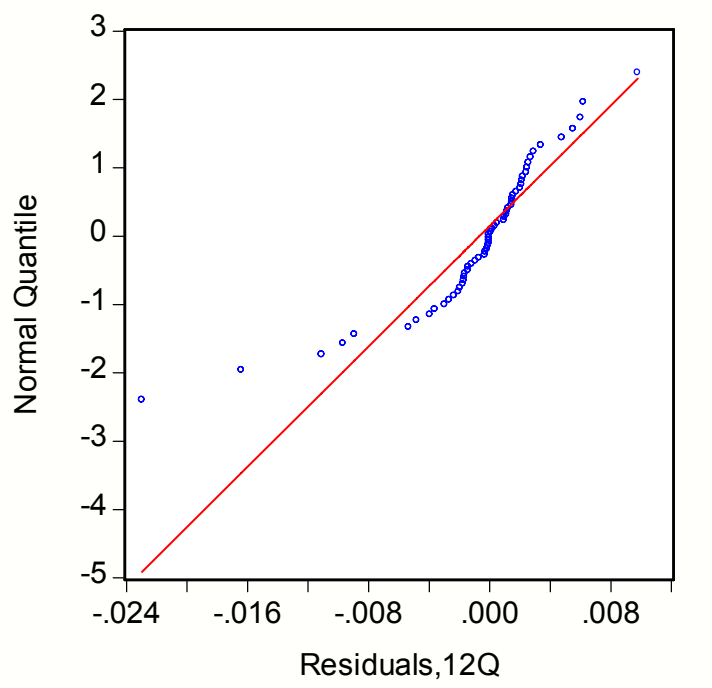


Figure A2.4 **Kernel density, Spain (12Q)**

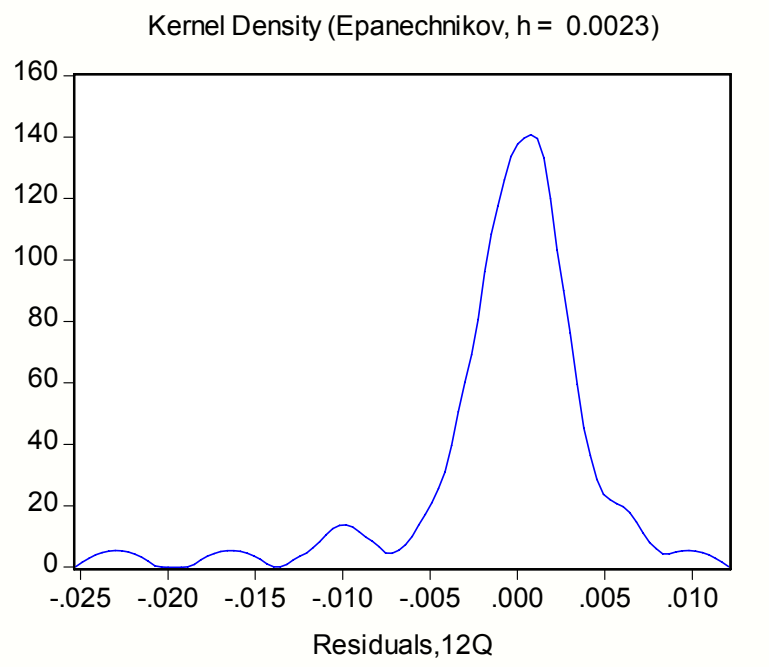


Figure A2.5 **Theoretical Quantile-Quantile, Germany (12Q)**

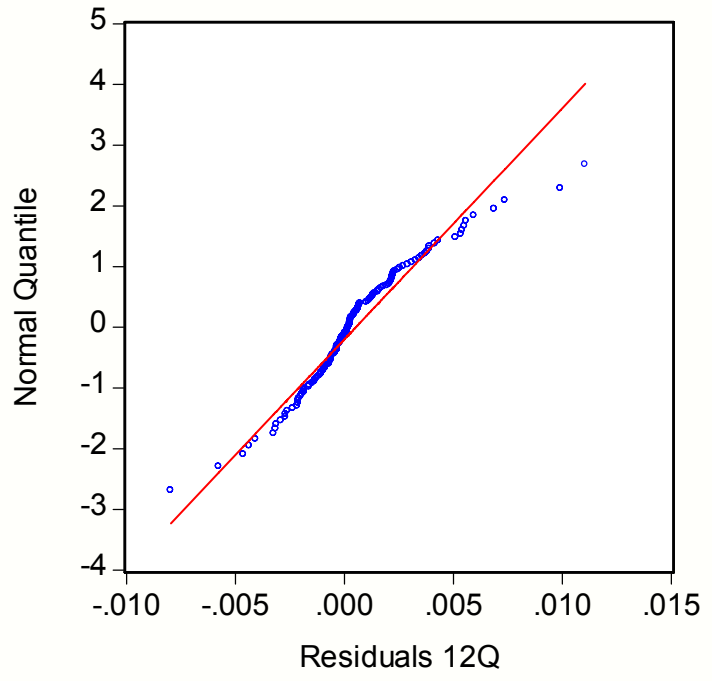


Figure A2.6 **Kernel Density, Germany (12Q)**

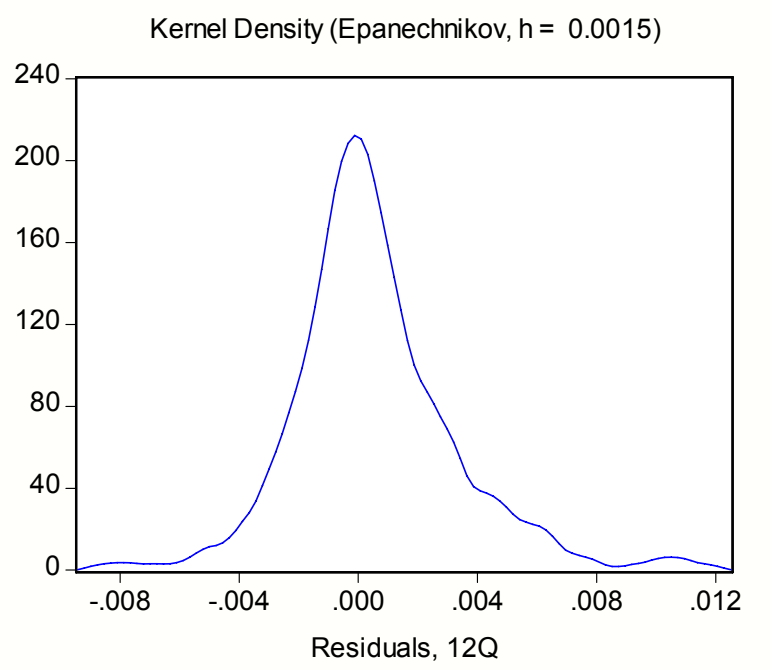


Figure A2.7 **Theoretical Quantile-Quantile, UK (12Q)**

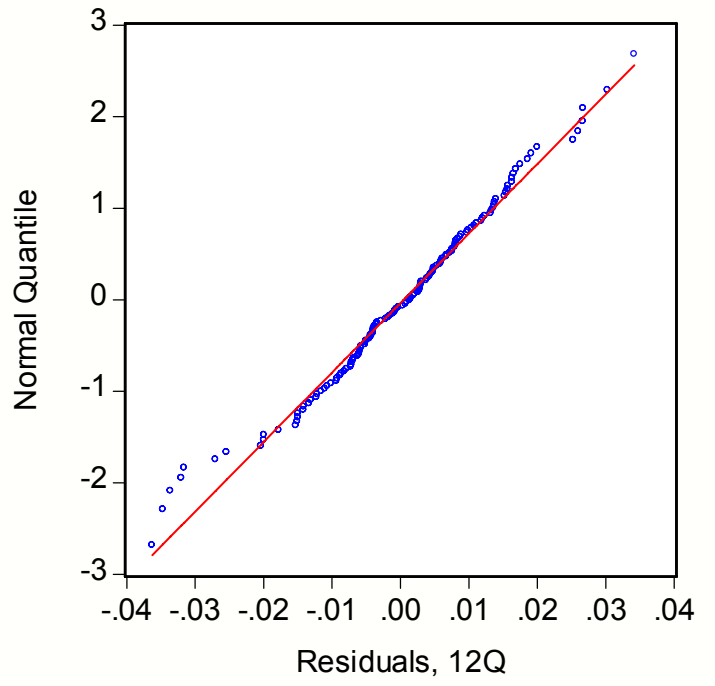


Figure A2.8 **Kernel Density, UK (12Q)**

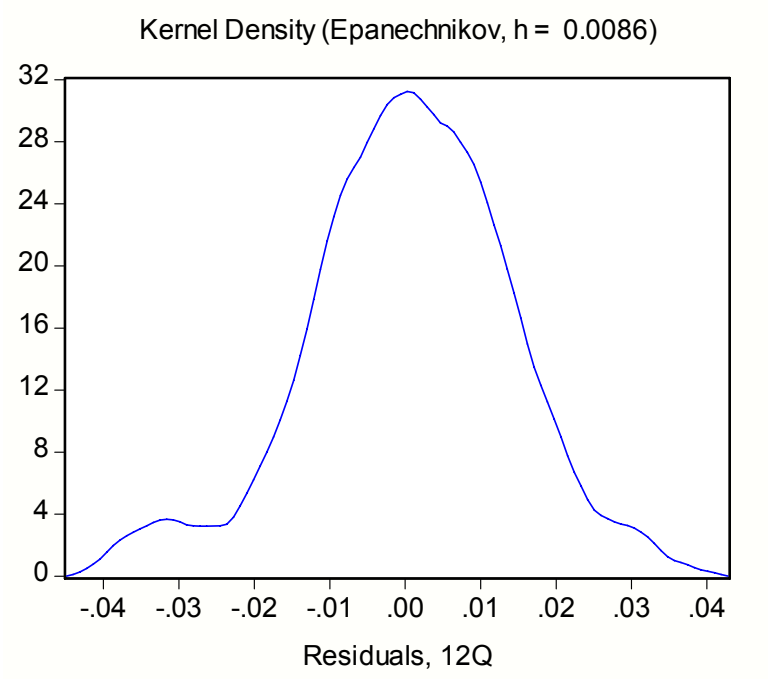


Figure A2.9 **Theoretical Quantile-Quantile, USA (12Q)**

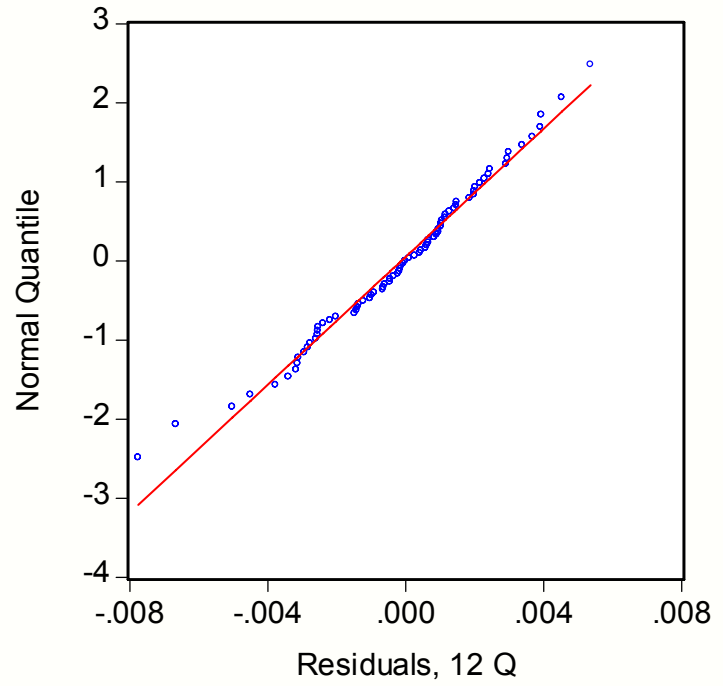
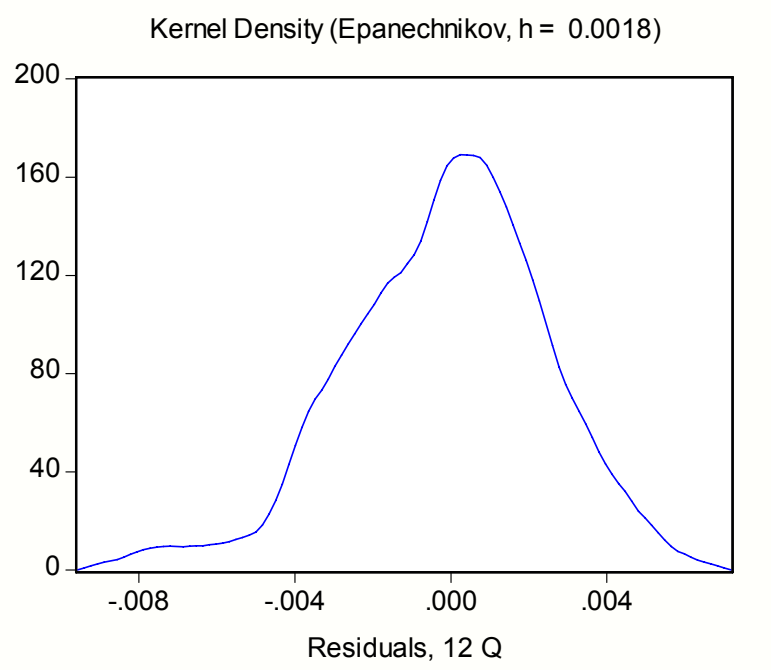


Figure A2.10 **Kernel Density, USA (12Q)**



Appendix 3

Bubble-indications by using a 36 months rolling window

The regression (3.10) was always estimated by using last 36 months dividend yield data.

Figure A3.1 **Real estate bubble indications, Finland**

Figure A3.2 **Real estate bubble indications, Germany**

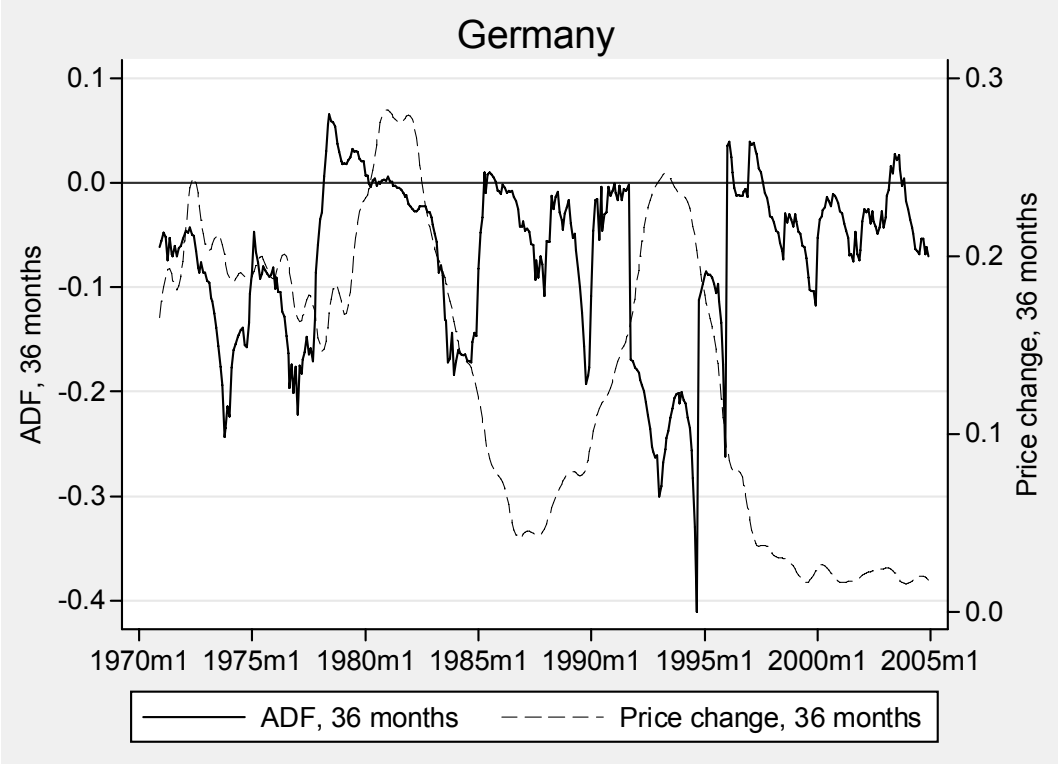


Figure A3.3 **Real estate bubble indications, Spain**

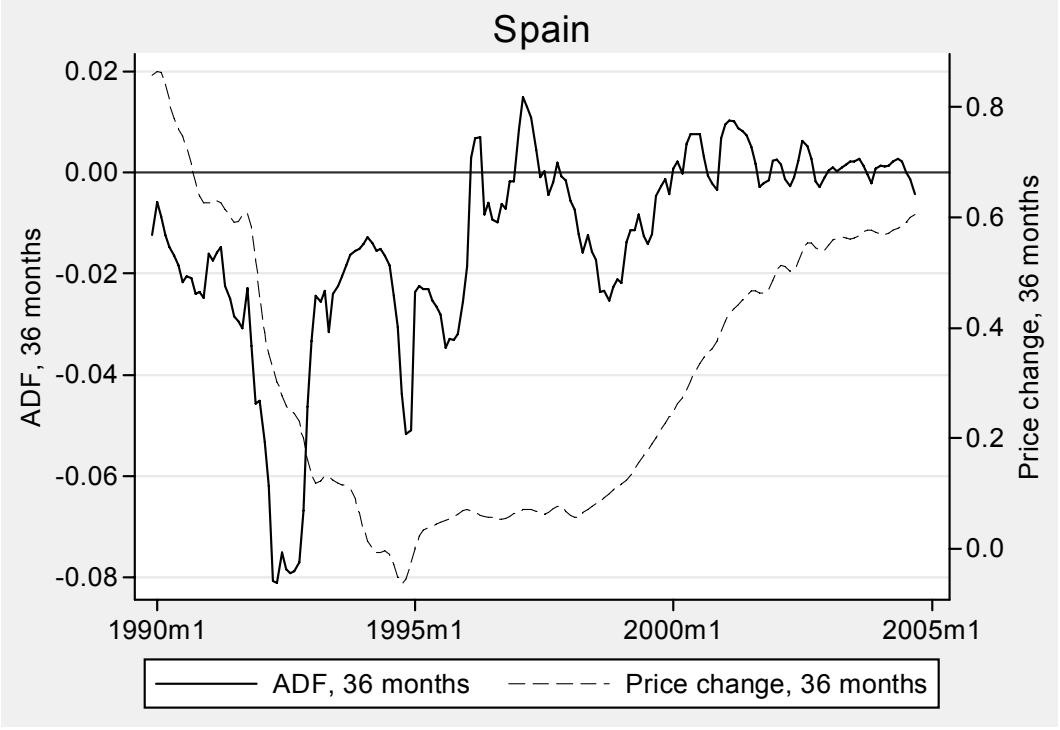


Figure A3.4 **Real estate bubble indications, UK**

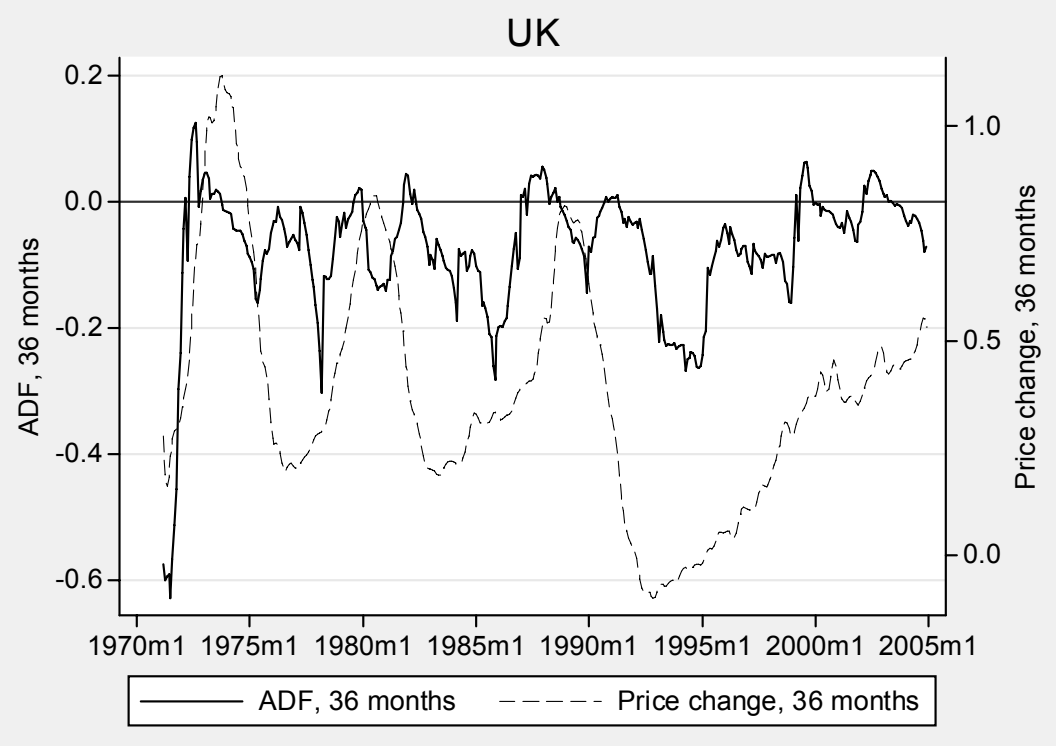
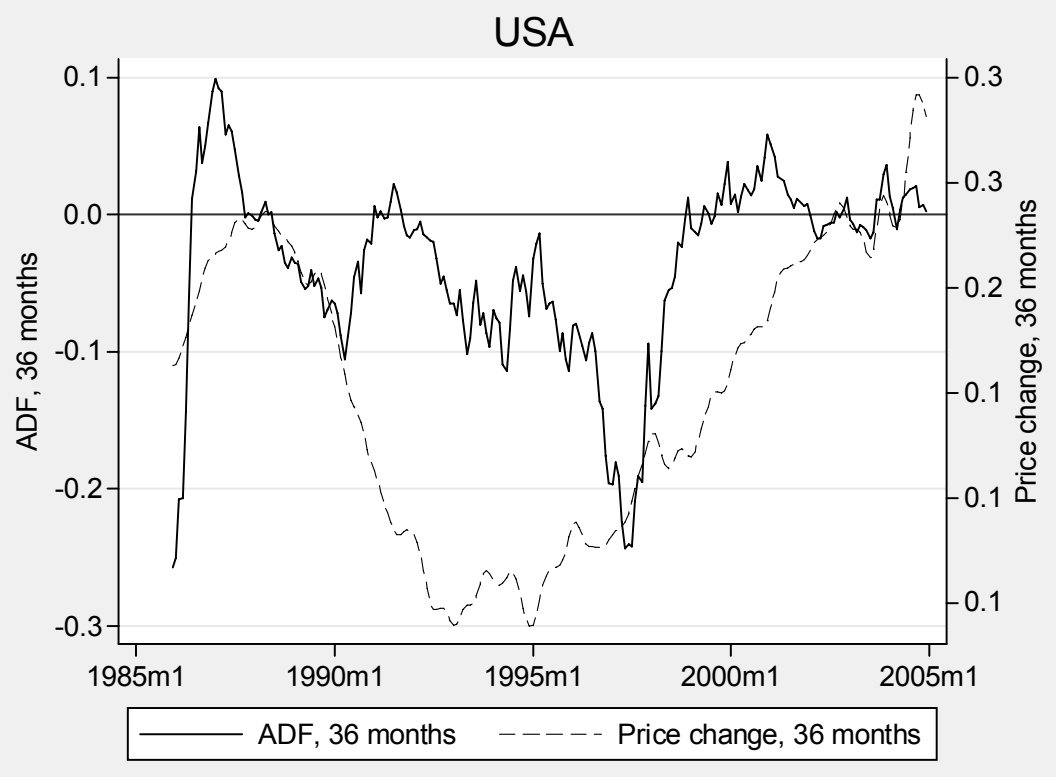


Figure A3.5 **Real estate bubble indications, USA**



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