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Speculative Bubbles in Urban Housing Markets in Germany

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Abstract

In the light of the unconventional monetary policies by most large central banks around the world, there is an intense debate about the potential impact on the prices of capital assets. Particularly in Germany, skepticism about the sustainability of the recent policy by the European Central Bank is widely spread and concerns about the emergence of a speculative price bubble are raised. However, studies on bubbles in house prices are scarce and provide mixed results. Moreover, the evidence on German property prices is either based on national indices, neglecting city-level heterogeneity, or based on a non-representative sample of cities, or consider a time period that is relatively short. The present study analyzes a comprehensive data set covering 127 large German cities over the last 20 years. Using state-of-the-art methodology we test for speculative bubbles both at a national and city level. Furthermore, we apply two new testing approaches: panel data and principal components versions of explosive root tests. We find evidence for explosive price increases in many cities, especially for newly built housing. However, only in some urban housing markets, prices decouple from their fundamental values. On the national level there are no speculative price movements. Overall, our findings indicate that the threat of a speculative price bubble in the German housing market is moderate.

Keywords: housing prices, speculative bubble, explosive root, German cities.

JEL classification: C21; C23; C53.

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1 Introduction

After a protracted period of stagnation, German house prices began to grow at an accelerated pace (see Figure 1). Real house prices, which had even been declining in 2000-2008, started to climb up steeply from the second half of 2010, followed by a substantial increase of construction activities. Having the lessons from the Great Recession in mind (Duca et al., 2010), current housing market dynamics raised concerns about the formation of a speculative house price bubble in Germany. In 2013, the German Central Bank reported an overvaluation of house prices in some metropolitan areas of up to 25% (Deutsche Bundesbank, 2013; Kajuth et al., 2013). In response, the International Monetary Fund (IMF) called on the German government for an enhancement of its macro-prudential toolkit to be prepared for the case of an overheating housing market, which the IMF identified as a potential threat to financial market stability (IMF, 2014). In the light of the extremely expansionary monetary policy of the European Central Bank (ECB), the German minister of finance, Wolfgang Schäuble, said in July 2014 that he would take the warnings seriously and keep a close eye on future housing market developments.

In contrast, other discussants do not see the need for immediate intervention. They argue that, in international comparison, German house prices are relatively low and house price movements are modest against the background of Germany's sound macroeconomic fundamentals, a growing number of immigrants, and increasing rents (Haas et al., 2013; Henger et al., 2012). Moreover, it is argued that house price increases are concentrated in selected urban markets—particularly in the prosperous metropolitan areas like Berlin, Hamburg, and Munich—cities experiencing substantial economic and population growth (Dombret et al., 2013), while in more rural areas house prices remain unchanged at low levels. Finally, it is argued that a speculative house price bubble is always associated with a substantial increase of outstanding mortgage loans and excessive construction activity; both do not apply for real estate investment in Germany. Consequently, descriptive assessments of the housing market conclude that there are no indications of bubbles in German housing markets (Empirica AG, 2014; IMF, 2014).

However, there are good reasons to believe in both stories behind the numbers. Taking a historical perspective over the past 140 years, Jordà et al. (2014) point out that the ingredients (particularly loose monetary policy) for a substantial misalignment between house prices and economic fundamentals are present, which make the

arguments by the German Central Bank and the fears of the IMF appear valid. On the other hand, authors like [Kofner \(2014\)](#) emphasize the stability and the resilience of the German housing market to external shocks.

A key challenge in this context is that the real-time identification of a bubble is relatively complex and simply relying on a descriptive analysis of isolated indicators can be misleading. So far, there have been three studies to address a potential house price bubble in Germany that employ more advanced econometric techniques.

The most prominently cited work is that of [Kajuth et al. \(2013\)](#), who follow a “classical” approach by regressing house prices on market fundamentals. Using data for more than 400 regions in the period from 2004 through 2012, they capture the entire spatial variation of the German housing market. [Kajuth et al. \(2013\)](#) find that for most regions analyzed, house prices reflect the economic conditions quite well. However, in metropolitan areas, a substantial overvaluation of up to 25% is detected. In part, this can be attributed to the fact that the time dimension of the data is rather short. The authors estimate an “equilibrium” price in the period from 2004 through 2010 and compute the fundamental price for the period from 2010 onwards using the estimated coefficients. However, assuming that housing markets were in equilibrium in the period until 2010 is somehow counter-intuitive. At least during the great recession (2007-2009) the pricing mechanism should have been disturbed substantially, which could lead to biased estimates of fundamental prices during the post-crisis period.

Another study by [Chen and Funke \(2013\)](#), analyzes aggregate house price data from 1987 through 2012. The authors apply a relatively new approach proposed by [Phillips et al. \(2011\)](#), which essentially is a unit-root test for explosive behavior in time series data. The authors conclude that, on the aggregate level, no signs of a speculative house price bubble can be detected. However, the major shortcoming of this study is the use of national level house prices. As it is pointed out by several authors, house price dynamics vary significantly across regions ([Goodman and Thibodeau, 2008](#); [Hwang and Quigley, 2006](#); [Abranham and Hendershott, 1996](#)). Thus, signs of bubbles are hardly detectable in national time series data. For an early warning indicator, the use of regional data seems to be more appropriate.

The study by [an de Meulen and Micheli \(2013\)](#) picks up the spatial dimension of Germany’s housing market. The authors analyze monthly data of metropolitan house prices from January 2008 through January 2013. Based on more powerful tests, as proposed by [Homm and Breitung \(2012\)](#), they conclude that explosive price

dynamics can only be detected in selected regions and only for flats in apartment buildings. In summary, the authors conclude that signs of a speculative house price bubble are weak. Unfortunately, this study focuses on a very short period of time, a small number of cities and selected market segments, which raises doubts on the relevance of their findings for the whole country.

Of the aforementioned approaches, the univariate tests are particularly suitable for a real-time analysis of price dynamics, as they do not require co-variables that are regularly not available, at least on the sub-national level. However, the use of these tests comes at the cost that we cannot explicitly disentangle the influence of market fundamentals, like income or population growth, but also the potential influence of dramatically decreasing interest rates and returns from alternative assets. However, we indirectly consider these factors, as we follow a multi-level testing strategy. We separately analyze house prices and rents in all market segments on a national and on a regional level. If prices were driven by increased demand, rents should reflect this adequately on a city level. If interest rates were the key driver of housing market development, then national and regional price series should follow a similar trend. We argue that speculation is a likely driver of house price dynamics in markets where national and regional as well as rent and price series do not show a common pattern, i.e., regional prices contain an explosive root, while rents and national prices do not. As we argue later on, this result is particularly robust for small and less liquid markets.

The contribution of this paper is manifold. First, this study is based on a very large panel comprising 127 German cities and covering the period from 1996 through 2013. Using these data allows us to observe an entire housing market cycle and, moreover, to account for heterogeneity across urban housing markets. Second, we distinguish between different housing market segments. Compared to previous studies, this clearly increases plausibility of the analysis. Third, we further develop existing tests for price bubbles: We construct a panel-data version of the Chow-type test for explosive roots. This allows us to exploit all time series and cross-sectional variation to construct a more powerful method testing if there is a significant explosive root in at least one city. Moreover, we apply this test to the first principal components of the individual city-specific prices/rents, which reflect a common trend in the house prices/rents across various cities. Fourth, we use a more precise definition of a bubble: We define price movements as bubbles when explosive growth of prices is not supported by explosive increases of rents. Therefore, to check for the existence of bubbles, we examine not only prices but

also rents.

Our findings indicate, that prices for newly built apartments increase explosively on the national level. But this seems to be covered by corresponding rent increases. The prices for second-hand apartments do not contain an explosive root. In contrast, we detect explosive price increases in many cities, particularly in the market for newly built homes. However, only in some of them, prices appear to be disconnected from their fundamental values. Thus, our results imply that the signs for a speculative bubble are weak.

The paper is organized as follows. In section 2, we present stylized facts on the German housing market. Section 3 outlines our empirical strategy and presents the basic concepts and methods. Subsection 4.1 describes the data on house prices in German cities that are used in the study. Subsection 4.2 discusses the empirical setup of the study, while in subsection 4.3 the tests for speculative bubbles are carried out and their results are discussed. Finally, section 5 draws conclusions.

2 The German housing market: Four stylized facts

Before starting the statistical analysis of house price dynamics, we present some stylized facts on the housing market and set them in an historical and cross-country perspective. Overall, these numbers indicate that the German housing market on aggregate appears to be in good condition.

Stylized fact 1: Long period of declining real house prices. Unlike the markets in many other major economies, the German housing market did not experience a boom at the start of the 2000s. From 1996 to 2008, real house prices even declined (see Figure 2). This, however, can be interpreted as a response to the reunification boom in the early 1990s, when, especially in East Germany, price movements were not supported by economic fundamentals (Michelsen and Weiß, 2010).

Stylized fact 2: Affordability and risk taking behavior improving since the 1980. The moderate price development is also reflected in other indicators like the price-to-rent and the price-to-income ratio, both of which were declining since the 1980s in Germany. Around 2010 these measures picked up again (see Figure 2). In most other countries, price-to-rent and price-to-income ratios were much more volatile. In historical comparison, the current level of these measures can still be rated as moderate in Germany. However, the recent

increase of these ratios is quite strong, particularly that of the price-to-rent ratio, which indicates that investors are willing to take greater risks with real estate investment.

Stylized fact 3: Weak construction activity. Construction has been weak in Germany since the late 1990s (see Figure 2). In comparison to the early 1990s—the period shortly after reunification—housing permits dropped substantially. Investment in new dwellings and the ratio of residential real estate investment to GDP follow the same pattern. Both have been decreasing continuously since the mid-1990s. All three indicators began to rise in 2010, following the trend of real house prices. However, the recovery is, in comparison to earlier years and to other economies, relatively moderate. Housing investments in other countries tend to react more quickly to price movements and are much more volatile.

Stylized fact 4: Stable volume of new mortgage loans and high share of long-term fixed interest rates. The fourth stylized fact shows that, in contrast to typical Anglo-Saxon housing market developments, the current upswing of the German market is not associated with an increase of the volume of new credit to private households (see Figure 3). Since 2011, new housing lending remained relatively stable around 16 billion euros per month. Moreover, the share of new contracts with long- and medium-term fixed interest rates is high and stable, as well.

Overall, in the light of the protracted stagnation of house prices and rents between 2000 and 2010, sound economic fundamentals seem to cover recent price increases. Nevertheless, these findings do not necessarily imply that recent house price movements are sustainable on the regional level.

3 A conceptual framework of bubbles in house prices

Economists are often blamed for ignoring the build-up of the speculative house price bubbles and their harmful consequences for the world economy prior to the Great Recession. There have been plenty of signs of a misalignment between house prices and their fundamentals, like excessive lending to private households and sharply increasing prices and construction activity. Indeed, many studies published before 2007 found that house prices were not disconnected from their fundamentals (see, e.g., [Himmelberg et al., 2005](#); [Smith and Smith, 2006](#); [McCarthy and Peach, 2004](#)). In fairness, there were a couple of studies that indeed warned about a potential

house price bubble in major economies like the United States (see, e.g., [Case and Shiller, 2003](#); [Belke and Wiedmann, 2005](#); [Fernández-Kranz and Hon, 2006](#)). Detecting a bubble *ex ante*, however, is not as straightforward as declaring past price movements to be unsustainable. There are several well-established theories that may explain seemingly unsustainable developments by rational behavior of agents (for a comprehensive overview of the existing models, see, [Brunnermeier, 2008](#)).

Our analysis and empirical identification strategy of housing market bubbles follows the ideas of the *Gordon growth model* ([Gordon, 1959](#)). The underlying intuition is that stock prices are fundamentally determined by future dividends in the period of ownership and moreover by future asset price increases. Under the assumption of perfectly informed and rational agents, price increases are again solely determined by dividends earned in the period after the next sale.

In the real estate context, this implies that house prices are—in the long run—tied to the development of rents. Under the standard no arbitrage condition, the house price can thus be expressed as

$$P_t = \frac{E_t[P_{t+1} + R_{t+1}]}{1 + i}, \quad (1)$$

where P is the real estate price, R denotes the rental income, t is the current time period, i the risk-free interest rate, and $E[\cdot]$ the rational expectation, conditional on the information available (see [Homm and Breitung 2012](#); [an de Meulen and Micheli 2013](#)). The fundamental price P^F can be determined by forward iteration of equation (1):

$$P_t^F = \sum_{n=1}^{\infty} \frac{1}{(1+i)^n} E_t[R_{t+n}]. \quad (2)$$

However, there is a unique solution for equation (2) under the transversality condition

$$\lim_{k \rightarrow \infty} E_t \left[\frac{1}{(1+i)^k} P_{t+k} \right] = 0. \quad (3)$$

If the actual price process contains additional elements, like a bubble component B , the pricing equation becomes

$$P_t = \lim_{k \rightarrow \infty} E_t \left[\frac{1}{(1+i)^k} \cdot \left(\hat{P}_{t+k} + (1+i)^k B_t \right) \right] + P_t^F. \quad (4)$$

In this case, there are infinitely many solutions. Today’s house price can be decomposed in two elements—one covering the fundamental value, determined by future rental income and another that is related to potentially speculative motivations. In case of a bubble, any rational investors should expect the house price to increase at rate i . Price increases then become self-fulfilling prophecies. Because all rational investors expect other investors to pay a price $P_{t+1}^F + B_{t+1}$, they are willing to pay $P_t^F + B_t$ in period t .

There are three major approaches to empirically identify the existence of a speculative bubble in housing markets. The first approach detects the boom and bust periods in housing prices as deviations from some trend (e.g., moving average, Hodrick-Prescott trend, or as defined by the [Harding and Pagan \(2002\)](#) method). This literature is thoroughly discussed in [Agnello and Schuknecht \(2011\)](#).

The second approach identifies the house price misalignments by comparing the actual price with that supported by the fundamental factors, see [Kajuth et al. \(2013\)](#) and [Kholodilin \(2012\)](#), among others.

Finally, the third approach relies upon statistical tests of the so-called explosive roots. Recently, [Phillips et al. \(2011\)](#) and [Homm and Breitung \(2012\)](#) developed empirical tests to identify unusually strong increases in asset prices. The basic idea is to analyze the roots of an autoregressive process. If asset prices represent discounted expected incomes—in the housing context rental income—it is unlikely that prices grow at an exponential rate in the long run. The approach to detect a bubble is to test for an explosive root against the alternative of a unit root, the latter reflecting the rational expectations hypothesis. Among others, [Kivedal \(2013\)](#) and [Clark and Coggin \(2011\)](#) already implemented this idea in the housing context. In contrast to the [Homm and Breitung \(2012\)](#) and [Phillips et al. \(2011\)](#) tests, which are univariate procedures, the framework developed by [Kivedal \(2013\)](#) allows to test a theoretical model and particularly to consider interest rates as potential driver of house price dynamics.

4 Empirical analysis

We follow the univariate approach proposed by [Homm and Breitung \(2012\)](#). We do so, because we are particularly interested in the price dynamics on the regional level. We argue that in a real time monitoring context of real estate bubbles, the regional level is the relevant dimension to look at. Housing is spatially fixed and markets are regionally segmented. Thus, national time series are the least to reflect speculation in house prices. However, using regional time series comes at the cost that we cannot include market fundamentals directly, as these statistics are regularly published with a time lag of several years. This is particularly true for the determinants of demand and supply, like income, the housing stock or population. However, we indirectly consider demand and supply fundamentals as we also analyze rents and test, whether their development is in line with the surge of house prices.

Further, it can be argued that interest rates were the key driver of the recent price increases. However, it can be argued that the costs of borrowing money are spread quite evenly across the country ([Reichert, 1990](#), p. 388). There should also be no differences in the returns of alternative investments as stocks or bonds are traded on world markets and interest rates are determined by European monetary policy. *Ceteris paribus*, a global change in interest rates should enter investors' rationale (in terms of a lower internal discount rate) equally across markets. This implies a uniform effect of interest rates on house prices. Thus, if we observe explosive behavior in single markets but not in the national series, this would imply that price increases were unlikely a result of changes in the interest rates.

However, given the specific situation of very low interest rates, one can argue that price markups may also be driven by a change in investment motives: more explicitly, one can argue that different types of (international) investors enter the market who are interested to invest in more liquid assets or are less informed about the specific investment opportunities. Therefore, they tend to invest in the large metropolitan areas, like Berlin, Hamburg, or Munich. This would imply that the premium for liquidity and information changes, which might also serve as explanation for different house price dynamics ([Kraimer, 2001](#)). Particularly, this is a problem for the interpretation of our results in large and more liquid markets, where we cannot disentangle these effects. But, in turn, this allows for an even stronger interpretation of the results for smaller cities, where information is scarce and liquidity is lower.

Consequently, we follow a multi-level test strategy: First, we analyze whether an explosive behavior can be detected in national time series. If so, we evaluate the national series for rents and analyze if the dynamics of purchase prices were in line with that of market fundamentals. In the next step, we analyze disaggregated data for 127 urban housing markets. In this context, we again argue that the likelihood of a speculative bubble is high if prices grew explosively, while rents did not. This result would be even strengthened for the case of explosive price dynamics in “cold” markets, while conclusions about the existence of a bubble are more ambiguous in large, more liquid markets.

4.1 House price data

The German data on house prices and rents, especially for individual cities, are quite poor (see [Hoffmann and Kurz \(2002\)](#); [Hoffmann and Lorenz \(2006\)](#), and [Georgi and Barkow \(2010\)](#) for an overview of German house price data). Typically, the data are either short, cover a small number of locations, or reflect only advertised prices.

In the present analysis, we take advantage of a data set on prices and rents that is provided by real estate analysts of *bulwiengesa AG*. The company has been collecting real-estate data and constructing corresponding price indices for over 30 years¹. These data are used, among others, by the German Central Bank to examine the developments in the German real-estate market. Furthermore, OECD utilizes the data to construct German-wide house price index for its international database.

The data set covers average transaction prices and rents for 127 large German cities from 1990 through 2013. This makes it unique in terms of its geographical and temporal coverage. More importantly, the use of these data allows us to tackle main weaknesses of previous studies on the German housing market (see section 1).

In our analysis, we concentrate on the following four price series:

- average purchase price of newly built apartments;
- average purchase price of second-hand apartments;
- average rent of newly built apartments; and
- average rent of second-hand apartments.

¹For more details see [Hampe and Wenzel \(2011\)](#).

The dynamics of purchase prices and rents in all cities are depicted in box plots to characterize their distribution (Figure 4). In both market segments (primary and secondary markets) prices increased strongly starting in 2010. To ensure, that the tests applied indicate a bubble in the current upswing of house prices, we drop the observations from the early 1990s and start our analysis in the year 1996. Particularly cities in the former GDR experienced a boom in the years after the reunification.

Further *bulwiengesa* data provide a rating of the locations in Germany, ranging from A to D, which became a standard classification for German real estate professionals. *A* stands for the most important German markets. Seven cities fall in category *A*: Berlin, Hamburg, Munich, Cologne, Duesseldorf, Frankfurt, and Stuttgart. *A*-cities are characterized by international or at least nation-wide importance, high turnover of real estate transactions (annually $> 2.5\%$ of the market), and overall sound market conditions. According to *bulwiengesa*, 14 cities are rated *B*. *B*-markets are of national and regional importance and have an annual turnover of around 1.5% of the total market. *C*-rated markets (22 cities) are of regional importance and have less impact on national market development. Cities of category *D* (84) are predominantly local centers. Liquidity in *C* and *D* locations is significantly below *A* and *B* markets.

4.2 Empirical setup

To test for explosive roots in the German house price and rent data, we apply the Chow-type unit root statistic. Before analyzing the data on the city level, we extract the first principal components of the price and rent series and test for explosive roots. The reason for this is twofold. Firstly, the individual city-level time series are relatively volatile, whilst the principal component should be smoother due to canceling out of the individual fluctuations. Secondly, the first principal component can be interpreted as a countrywide house price trend and, provided that a speculative bubble will be discovered, it can be treated as a house price bubble at the national level. The resulting factor loadings can be interpreted as contributions of each city to the national bubble.

Next, we develop a panel-data version of the Chow-type test for explosive roots. The panel data allow to exploit the cross-section dimension, given a very short time dimension of our data. Here, we examine a null hypothesis of no explosive roots in any of the city-level housing markets. Finally, we investigate each price series on the city level separately. The rejection of the null is a minimum condition for the existence of a bubble in

the German housing market.

Given the very short sample of house prices in German cities, we need to investigate the size and power of the test when applied to very short samples. In order to do this we carry out simulations that are conducted using a framework suggested by [Homm and Breitung \(2012\)](#). We generate an AR(1) process with a time-varying autoregressive parameter:

$$y_t = \rho_t y_{t-1} + u_t \quad (5)$$

where u_t is a white noise process such that $E(u_t) = 0$, $E(u_t^2) = \sigma^2$, and $y_0 = c < \infty$.

$$\rho_t = \begin{cases} 1, & \text{for } t = 1, \dots, [\tau^* T] \\ \rho^* > 1, & \text{for } t = [\tau^* T] + 1, \dots, T \end{cases} \quad (6)$$

Thus, this process models a single deterministic bubble that occurs after time $[\tau^* T]$.

Simulations were conducted for various values of ρ^* , τ^* , and T . We considered the following values of the autoregressive parameter $\rho^* \in [1.03, 1.05]$ and the time fraction $\tau^* \in [0.7, 0.8, 0.9]$ that resemble the German case the most, given that the price increase started in 2010, that is, in 0.875-th fraction of the sample. Only one value of sample length was used, namely $T = 20$, which corresponds to a real-life situation where only 20 years of observations are available. The number of replications is 2000. One test statistic was used that turned out to be the best, according to [Homm and Breitung \(2012\)](#): The Chow-type unit root statistic for a structural break².

Simulation results for Chow test are reported in [Table 2](#). The empirical power of the test is very low. The break dates are detected very imprecisely. The good news is a relatively low size of the test. Thus, if the test would reject the null hypothesis of no speculative bubble, its results should be considered as relatively robust.

To our knowledge, this paper is the first to apply a panel version of the Chow type explosive root test. Its test statistic is computed as the mean of the city-specific Chow type test statistics. The critical values for this test were obtained using bootstrap as follows:

1. Growth rates, or differences of logarithms of the original price time series were computed: $\Delta y_{it} = y_{it} -$

²All the computations in this paper are carried out using the codes written by the authors in the statistical programming language **R** (see [R Core Team, 2013](#)). These codes are available upon request.

$y_{i,t-1}$.

2. The growth rates were collected in a vector $\Delta y_t = (\Delta y_{1t}, \Delta y_{2t}, \dots, \Delta y_{Nt})$.
3. Out of this vector the values were drawn with replacement: Δy_{it}^* .
4. Simulated series were generated using the bootstrapped growth rates: $y_{it}^* = y_{i1} + \Delta y_{i2}^* + \dots + \Delta y_{it}^*$. The number of simulations was set to 1000.
5. The Chow type tests for explosive roots were carried out for each city and then the panel test statistic was computed as the mean of the city-specific test statistics: $\bar{\tau}^{DFC} = \frac{1}{N} \sum_{i=1}^N \tau_i^{DFC}$, where τ_i^{DFC} is the Chow type test statistic for city i .
6. Based on the distribution of the mean test statistics, critical values were computed as 90th, 95th, and 99th percentiles.

4.3 Results

We first test whether explosive roots can be detected in the first principal components, which can be seen as a national time series. The first panel in Figure 6 shows the shares of variance of the price series explained by each principal component. The proportion of variance explained by the first principal component is 49% for newly built apartments and 36% for second-hand apartments. The second panel in Figure 6 shows the shares of variances explained by the principal components for the rents of newly built and second-hand apartments. The first principal component explains 46% of the former and 31% of the latter.

Figure 7 shows the first principal components of the prices of newly built and second-hand apartments (first plot) and the first principal components of the rents of newly built and second-hand apartments (second panel). The first principal components reflect the current house price cycle quite reasonable. They follow a downward trend from 1996 to 2005. Since 2008 the principal components grow and have largely overcompensated the preceding downward trend. Starting before 2000, the first principal components of the rents follow an upward trend, which has accelerated since 2010. However, for second-hand apartments, the increase slowed down a little in 2013.

The left side of Tables 2-5 shows the shares of variance of the prices that are explained by the first principal component, respectively for newly built apartments, second-hand apartments, rents of newly built apartments, and rents of second-hand apartments. They include the 10 cities for which the first principal component explains the highest share of the variance and the 10 cities for which the first principal component explains the lowest share of variance. The right hand side of the tables presents the weight each individual city has in the respective first principal component. They contain the 10 cities that have the highest and the 10 cities that have the lowest weights in the first principal component.

The variance of prices (Tables 3 and 4) and rents (Tables 5 and 6) can best be explained by the first principal component in booming western and southern German cities like Erlangen, Ingolstadt, and Ulm. But also the price developments in large East German cities like Leipzig, Dresden, and Berlin are quite well reflected in the first principal component. Many of the cities that are least explained by the first principal component are part of the regions that experienced a protracted deindustrialization over the last decades, particularly in the federal state of North Rhine-Westphalia, like Gelsenkirchen, Oberhausen, and Remscheid, but also Plauen in Saxony. The weights of each city of the first principal component largely correspond to the overall picture of the shares of variance.

Table 8 shows the Chow test statistics and the 1%, 5%, and 10% bootstrapped critical values for each of the 4 principal components. The bootstrapped critical values exceed simulated critical values at the 1% and 5% level of 2.6285 and 1.9327, respectively presented in Table 1 in [Homm and Breitung \(2012\)](#). Thus, the former are more conservative, than the latter. The null hypothesis can be rejected at the 1% level for prices of newly built apartments and at the 5% level for rents of newly built apartments. In our interpretation of the test, this implies, that recent house prices increases are well covered by a corresponding development of market fundamentals, i.e., rents. We cannot reject the null for both series of second-hand apartments. On the national level, no signs of a bubble can be detected in this market segment. Figure 8 illustrates the Chow-type statistic proposed by [Homm and Breitung \(2012\)](#) applied to the principal components. The suprema are represented by vertical lines of prices and rents for newly built and second-hand apartments, respectively.

In the second step, we examine the prices at the city level. We first test for explosive in each individual time series separately and then perform a panel-version of the Chow-test. In case of newly built apartments,

the null hypothesis can be rejected for 61 cities. This is also the case for second-hand dwellings in 19 cities, respectively. However, we also detect explosive roots in rents for newly built and second-hand apartments in several cities. For new dwellings, this is the case in 35 cities, while for second-hand apartments in 32 cities explosive price increases can be observed.

However, speculation is only in some of these markets the likely driver of house price dynamics. Figure 5 shows the geographical distribution of cities, where explosive roots are found in prices, while no explosive roots can be detected in the corresponding rent series. Circles represent the segment of newly built apartments, while crosses stand for explosive roots in second-hand dwellings. In none of the cities both markets are affected. Our results indicate that in about one fourth of the sample (28 cities) prices of new apartments appear to be decoupled from demand fundamentals. Interestingly, this is the case in only two of the top locations in Germany, i.e., in Hamburg and Cologne, and four of the B-rated markets. Bubbles are mostly detected in small to medium sized cities, some of them having a prosperous university. In C and D markets, liquidity is much lower. In this case, we conclude, that the likelihood of a speculative bubble is quite high, while we cannot draw such strong conclusion for A and B rated markets. As outlined in section 3, here we cannot distinguish between speculative motives and the potential effect of a higher liquidity premium.

Table 1: Markets containing explosive roots in prices that are not covered by demand fundamentals

	Market rating	New apartments	second-hand apartments
liquid markets	A	2	1
	B	4	0
less liquid markets	C	8	2
	D	14	6
Total		28	9

In only nine cities prices of second-hand apartments contain explosive roots which are not reflected in rents. With the exception of Potsdam, the cities are spread relatively uniformly over West Germany. Only one city of the German top locations, Munich, is affected. The others are all C or even D-rated, which again suggests, that in these locations speculative motives dominate investors' rationale. Overall, the signs for speculation in the second-hand market are weak.

This is also confirmed by the panel Chow type test. The results are presented in Table 7. Mean test statistic exceed the 1% critical values in the case of newly built apartments. Thus, the null hypothesis of no city having

a speculative bubble can be rejected in favor of the alternative that some cities have speculative bubbles in this market segment. For prices of second-hand apartments, rents of newly built and second-hand apartments the null hypothesis can not be rejected.

Overall, the results provide mixed evidence. Some results indicate the existence of speculative bubbles, whilst other tests reject speculation. On the national level, the recent surge of house prices appears to be covered by demand fundamentals. The panel tests indicate, that in some cities prices in newly-built apartments might be driven by speculative motives. However, the null-hypothesis of no city containing a speculative bubble cannot be rejected in second-hand markets. On the city level, we find explosive roots in house prices in about half of the sample. But only in one fourth of the cities analyzed, prices appear to be decoupled from demand. Here, we distinguished between liquid and less liquid markets. We argue that in less liquid markets, the likelihood of speculation is much higher than in liquid markets. In this context, we find that many of the detected explosive roots can be found in C and D-rated cities. We interpret this as first indication for speculative behavior of investors. The good news is that explosive roots are only detected in the segment of newly built apartments, which represents only a tiny share of the total market.

5 Conclusions

There is an intense debate about the recent surge of house prices in Germany. Interest rates fell to historically low levels following the 2008 financial crisis and alternative assets lost their attractiveness. Coupled with an increased migration towards metropolitan regions, this led to strong house price increases, particularly in urban areas. However, there might be an unexplained, potentially speculative component, which can be a threat for financial stability and the entire economy.

The aim of this paper was to identify potentially non-sustainable price movements. Therefore, we refined existing tests for speculative house price bubbles and applied them to data from 127 large German cities in the period 1996 through 2013. To test for the existence of bubbles, we performed the Chow type unit root test for each city separately in a panel context and for the national trend represented by the first principal component. Based on this analysis, we can draw the following conclusions.

First, at the national level, our results do not indicate the existence of a speculative bubble in apartment

prices. While we detect explosive behavior in the first principal component of newly built apartment prices, these movements appear to be covered by the rent development, which is also of an explosive nature.

Second, we find explosive roots in about half of the cities analyzed. More precisely, the prices of newly built apartments increase by an accelerated pace in 61 cities, while for second-hand apartments this is the case in only 19 cities. However, rents increase explosively in 36 cities for newly built and in 31 cities for second-hand apartments, as well.

Third, our results suggest that prices decouple from their demand fundamentals in some urban areas. In total there are 37 cities that are potentially affected by a speculative bubble, mostly in west Germany and mostly in the segment of newly built apartments. The robust panel explosive root test only confirms the existence of a bubble in prices for newly built apartments (in at least one German city).

Finally, speculation is likely to be a investment motive in small to medium sized markets. 30 out of 37 potential bubbles are detected in C or D-rated cities.

While we find first evidence for speculative bubbles in selected urban markets, our results indicate that the German housing market overall still appears to be in good condition. In the majority, only the small market segment of newly built apartments is affected by potentially speculative investment behavior. Indeed, the housing built in 2013 made up just 0.5% of the total housing stock. When accumulated over the period 2009-2013, the newly built housing makes up only 2.2% of the housing stock in 2013. Our results are largely in line with the assessment of most housing market analysts who find that the German housing market is quite stable. However, while most discussants argue that there is no need to worry at all, we conclude that decision makers are well advised to have a close eye on the housing market and to keep track of regional market developments. While it is true that unlike in Spain or the United States, the boom in the German housing market is not credit driven on aggregate, this does not necessarily mean that housing lending on the regional level has not increased substantially. This might apply to other indicators on a regional level, as well.

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Appendix

Table 2: Chow test: empirical size, power, and estimated break dates for $T = 20$

Autoregressive parameter, ρ^*	Break point, τ^*	Size and power	Break date	
			Mean	St. dev.
size		0.059		
1.02	0.7	0.088	0.649	0.261
	0.8	0.076	0.656	0.262
	0.9	0.082	0.668	0.263
1.05	0.7	0.144	0.664	0.251
	0.8	0.129	0.680	0.246
	0.9	0.109	0.683	0.257

Table 3: Prices of newly built apartments: importance of first principal component for each city and of each city for first principal component

Share of variance explained by first principal component				Weight of each city in first principal component			
City	Highest value	City	Lowest value	City	Highest value	City	Lowest value
Ulm	30.1	Duisburg	1.1	Magdeburg	19.7	Essen	3.6
Offenbach (Main)	24.6	Bottrop	0.8	Dresden	16.5	Gelsenkirchen	3.1
Fulda	23.3	Bielefeld	0.6	Kassel	15.7	Hamm	3.0
Osnabrück	23	Gelsenkirchen	0.6	Coburg	15.6	Recklinghausen	2.5
Erlangen	22.2	Recklinghausen	0.5	Ravensburg	15.0	Herne	1.9
München	22.1	Herne	0.5	Bamberg	14.9	Lüdenscheid	1.9
Dresden	22.0	Lüdenscheid	0.4	Mainz	14.3	Bottrop	1.7
Ravensburg	21.6	Oberhausen	0.3	Osnabrück	13.9	Plauen	1.3
Friedrichshafen	21.3	Remscheid	0.2	Fulda	13.7	Remscheid	1.1
Magdeburg	21.1	Plauen	0.2	Schweinfurt	13.6	Oberhausen	1.1

Table 4: Prices of second-hand apartments: importance of first principal component for each city and of each city for first principal component

Share of variance explained by first principal component				Weight of each city in first principal component			
City	Highest value	City	Lowest value	City	Highest value	City	Lowest value
Erlangen	36.9	Bergisch Gladbach	0.5	Kassel	23.2	Salzgitter	2.6
Ingolstadt	30.1	Herne	0.5	Landshut	17.3	Recklinghausen	2.1
Kassel	27.3	Hagen	0.5	Magdeburg	16.8	Hagen	2.1
Friedrichshafen	26.9	Bottrop	0.3	Regensburg	16.0	Herne	2.1
Wilhelmshaven	22.1	Remscheid	0.2	Chemnitz	16.0	Remscheid	1.6
Mainz	21.9	Mülheim (R.)	0.1	Bamberg	15.3	Lüdenscheid	1.4
Freiburg (Br.)	21.7	Lüdenscheid	0.1	Oldenburg	15.3	Bochum	1.2
Kiel	20.9	Bochum	0.0	München	15.0	Marburg	-0.7
Braunschweig	20.7	Plauen	0.0	Ingolstadt	15.0	Plauen	-1.0
Oldenburg	18.6	Marburg	0.0	Wilhelmshaven	14.7	Mülheim (R.)	-1.2

Table 5: Rents of newly built apartments: importance of first principal component for each city and of each city for first principal component

Share of variance explained by first principal component				Weight of each city in first principal component			
City	Highest value	City	Lowest value	City	Highest value	City	Lowest value
Erlangen	61.9	Salzgitter	6.0	Recklinghausen	2.1	Karlsruhe	-12.6
Offenburg	58.1	Aschaffenburg	5.8	Hagen	0.7	Passau	-12.7
Düsseldorf	56.0	Oberhausen	5.2	Bottrop	-0.8	Trier	-13.1
Dresden	54.0	Remscheid	4.5	Wuppertal	-1.8	Hannover	-13.2
Göttingen	52.0	Kaiserslautern	2.4	Dessau	-1.9	Braunschweig	-13.3
Bielefeld	50.6	Recklinghausen	1.7	Oberhausen	-2.6	Weimar	-13.8
Ravensburg	49.7	Wuppertal	1.5	Remscheid	-2.8	Leipzig	-14.7
Berlin	49.3	Dessau	1.2	Kaiserslautern	-3.1	Ravensburg	-15.0
Lübeck	48.3	Bottrop	0.6	Solingen	-4.0	Bayreuth	-15.5
Lüneburg	48.1	Hagen	0.5	Mönchengladbach	-4.1	Dresden	-18.7

Table 6: Rents of second-hand apartments: importance of first principal component for each city and of each city for first principal component

Share of variance explained by first principal component				Weight of each city in first principal component			
City	Highest value	City	Lowest value	City	Highest value	City	Lowest value
Ravensburg	65.8	Krefeld	1.2	Cottbus	29.2	Suhl	-13.6
Lüneburg	64.5	Erlangen	1.0	Greifswald	19.2	Lüneburg	-13.7
Hildesheim	60.5	Duisburg	0.6	Schwerin	17.0	Passau	-13.9
Ratingen	59.3	Halle (Saale)	0.6	Gera	15.3	Hildesheim	-14.0
Suhl	58.5	Bielefeld	0.4	Chemnitz	8.2	Konstanz	-14.6
Gießen	52.7	Mönchengladbach	0.4	Rostock	7.3	Darmstadt	-14.7
Salzgitter	49.8	Dessau	0.3	Hagen	5.8	Oldenburg	-14.9
Lübeck	49.6	Recklinghausen	0.3	Oberhausen	3.9	Ravensburg	-15.1
Schwerin	48.2	Gelsenkirchen	0.2	Dortmund	3.7	Albstadt	-15.9
Darmstadt	46.4	Eisenach	0.1	Wuppertal	3.5	Bamberg	-17.2

Table 7: Panel Chow type test

Variable	Test statistic	Bootstrapped critical values		
		10%	5%	1%
Newly built apartments	2.64	1.92	1.95	2.02
Second-hand apartments	1.00	1.81	1.85	1.89
Rents newly built apartments	1.71	1.77	1.80	1.86
Rents second-hand apartments	1.82	2.12	2.17	2.26

Table 8: Chow type test for principal components

Variable	Test statistic	Bootstrapped critical values		
		10%	5%	1%
Newly built apartments	4.87	2.52	3.03	4.19
Second-hand apartments	-0.46	2.12	2.43	3.08
Rents newly built apartments	3.98	2.83	3.27	4.03
Rents second-hand apartments	3.47	4.10	4.60	5.46

Figure 1: House prices in Germany, 1970:q1–2014:q2

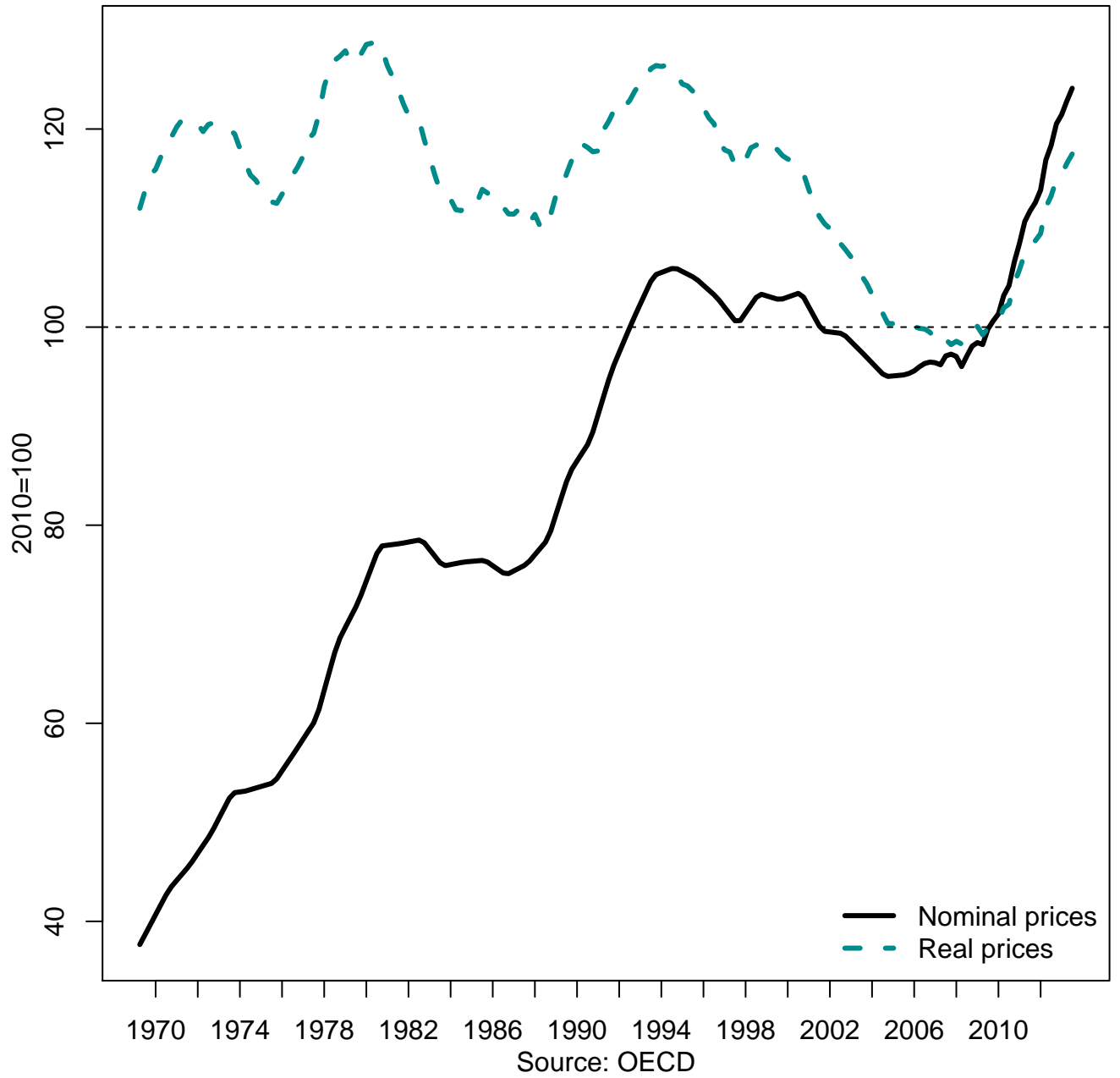
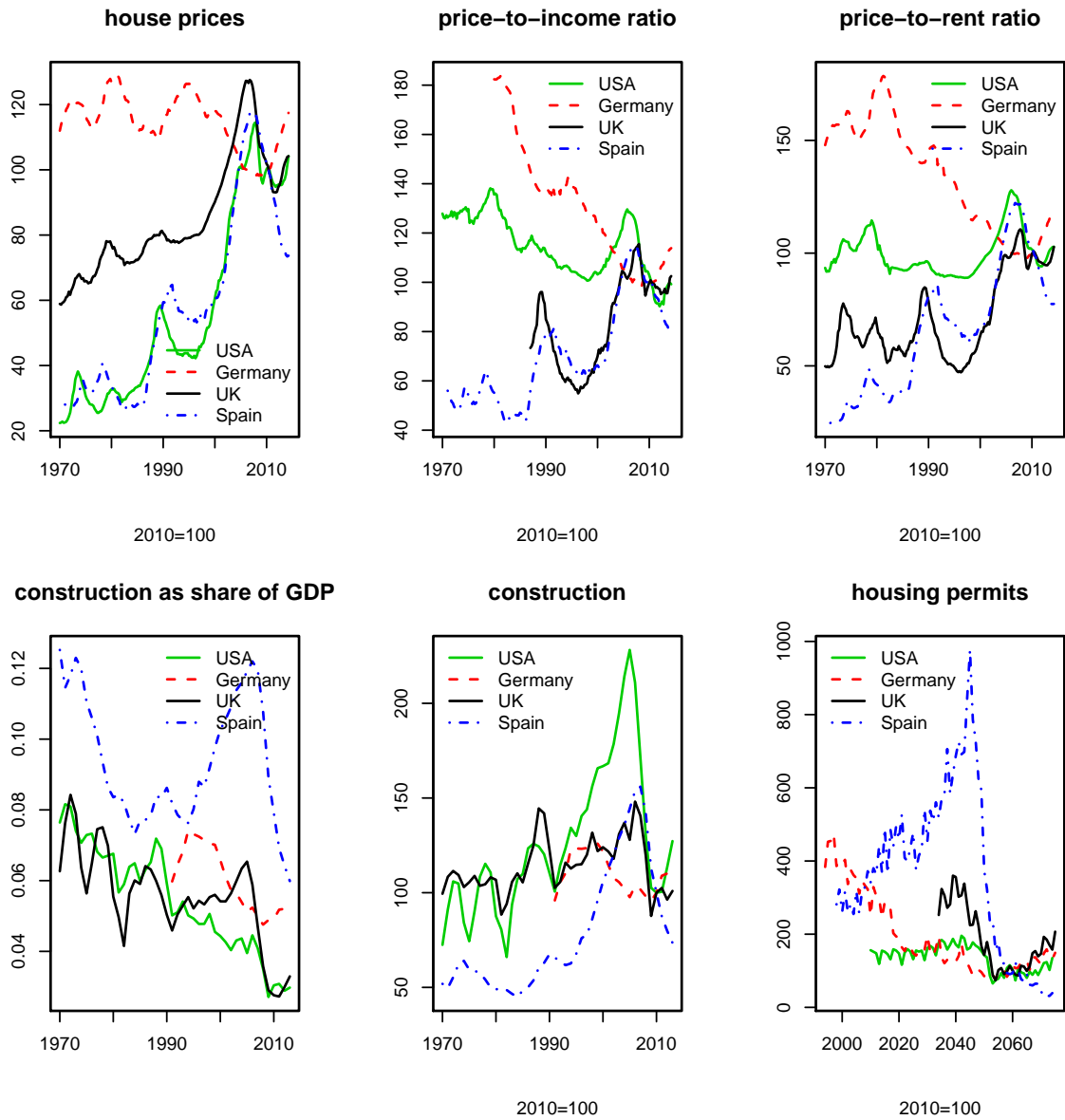
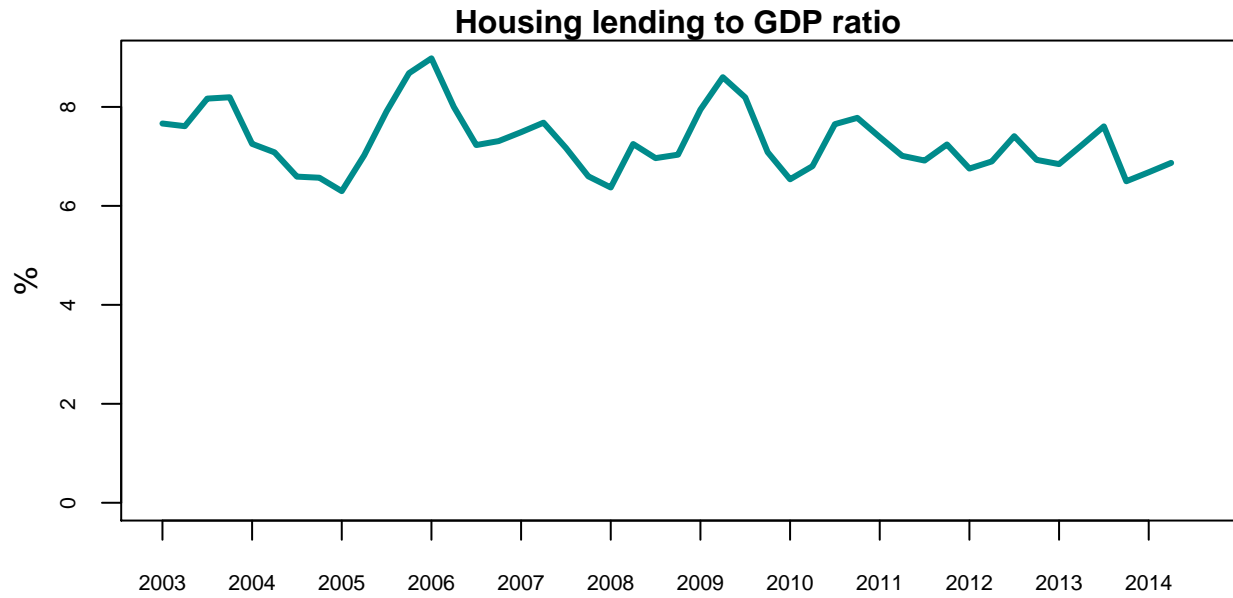
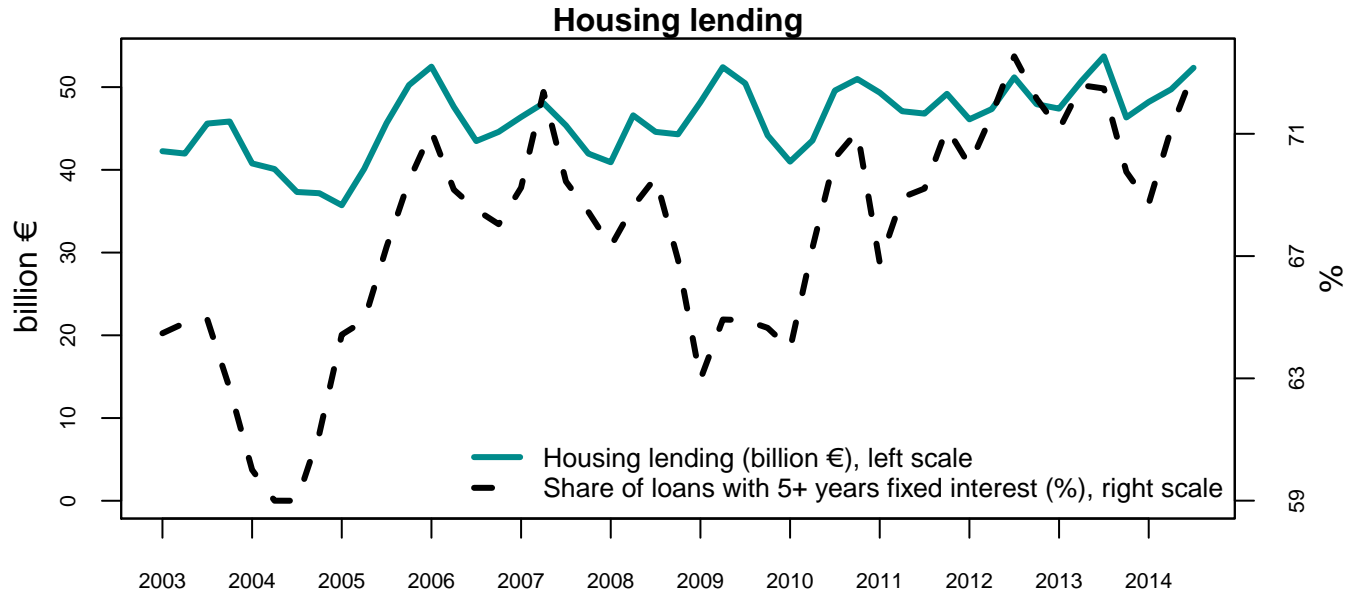


Figure 2: Stylized facts on housing markets in major economies



Source: OECD and Eurostat

Figure 3: Housing lending in Germany (new loans), 2003:q1-2014:q3



Source: Bundesbank

Figure 4: House prices and rents in German cities, 1990-2013

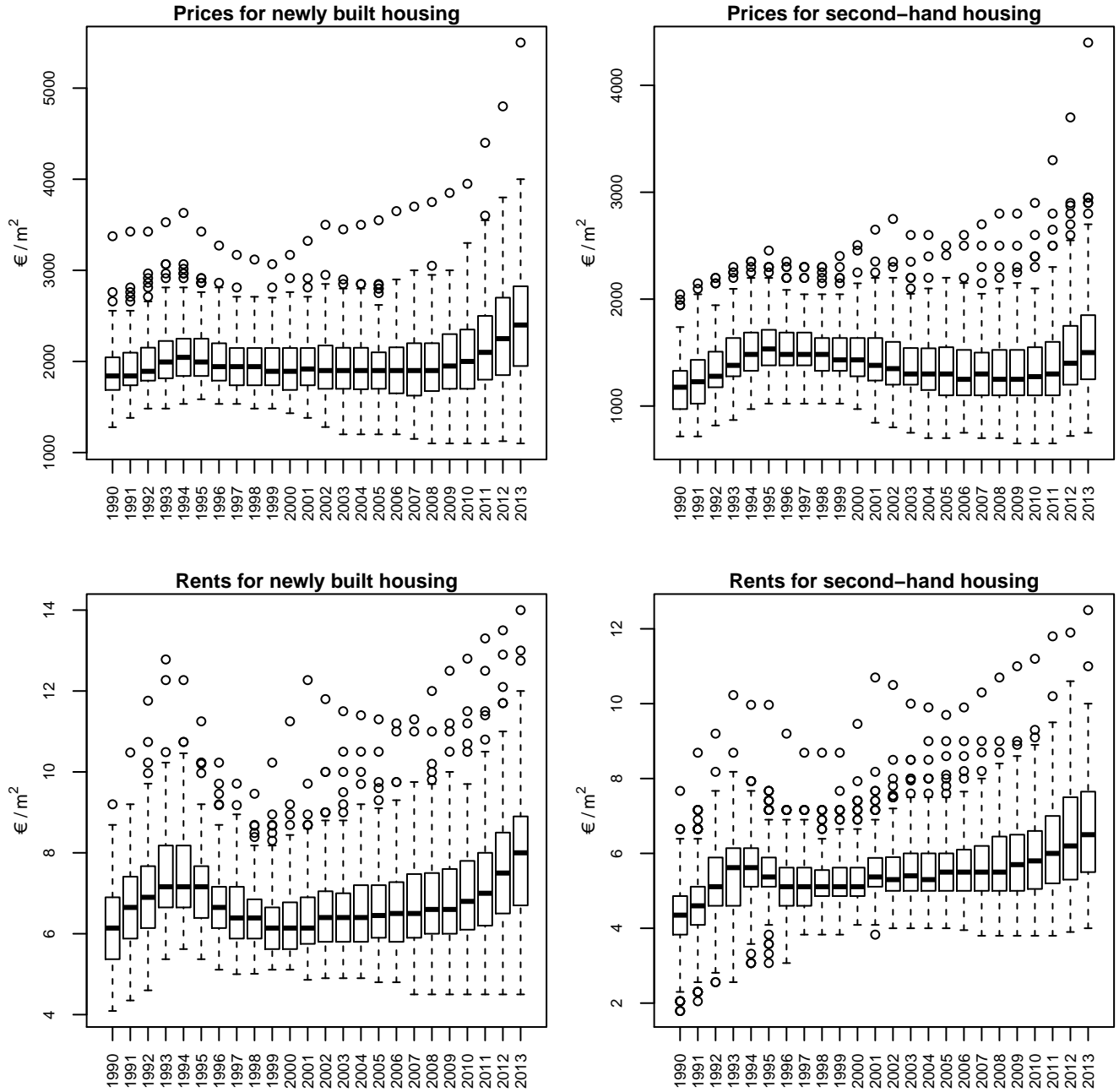


Figure 5: Geographical distribution of bubbles

○ Bubble of newly built apartment prices + Bubble of second-hand apartment prices

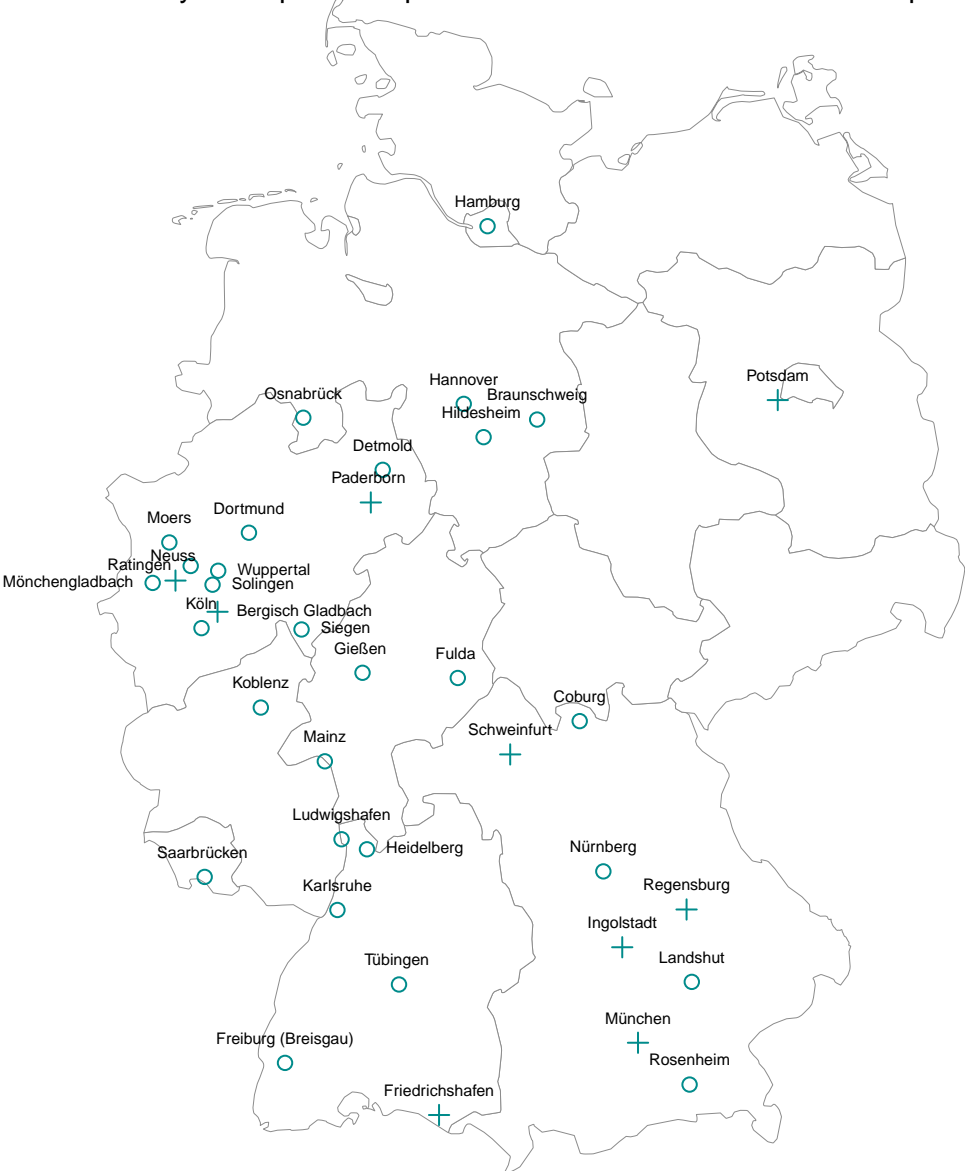


Figure 6: Principal components by share of variance

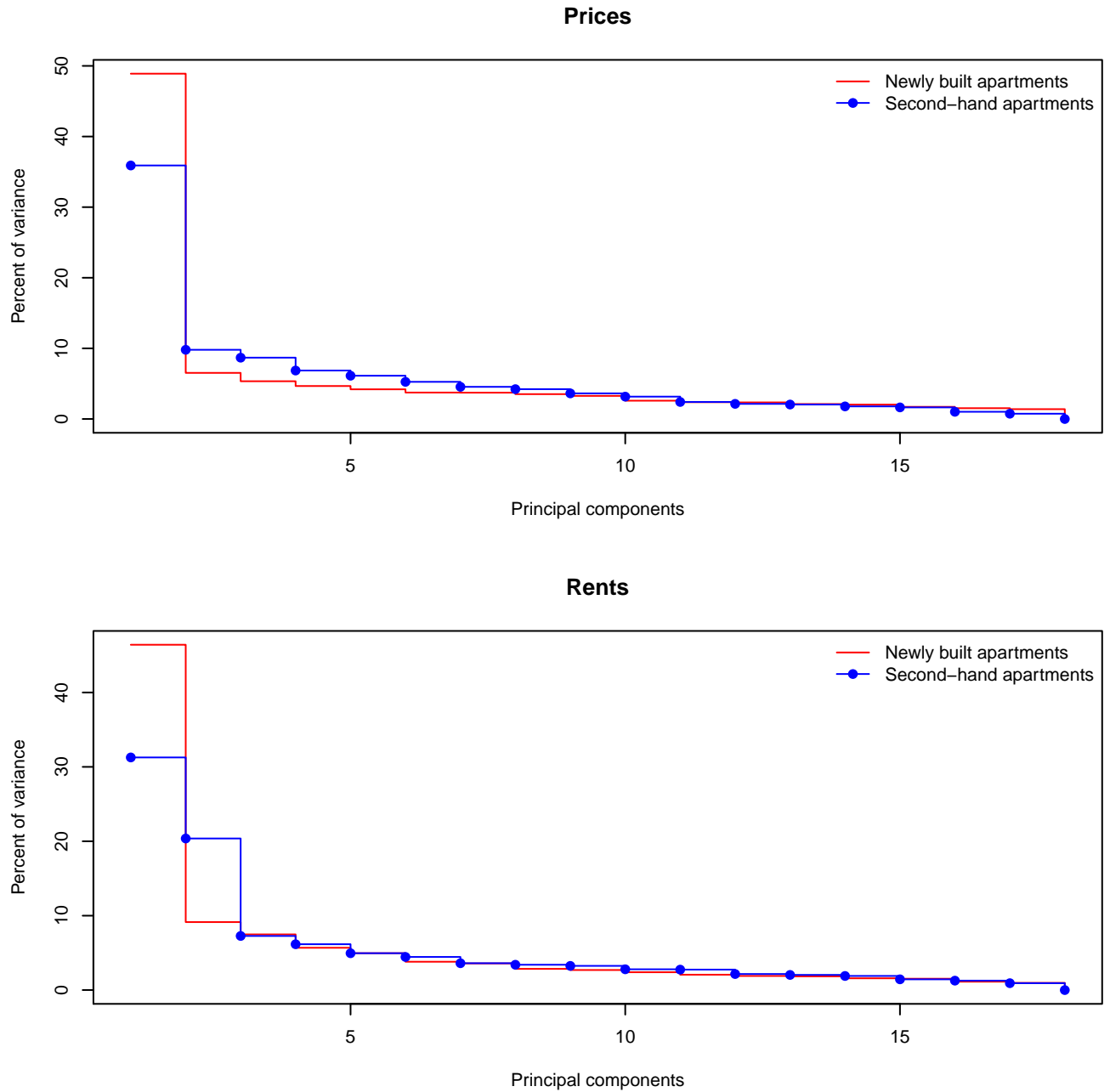


Figure 7: First principal components of housing variables

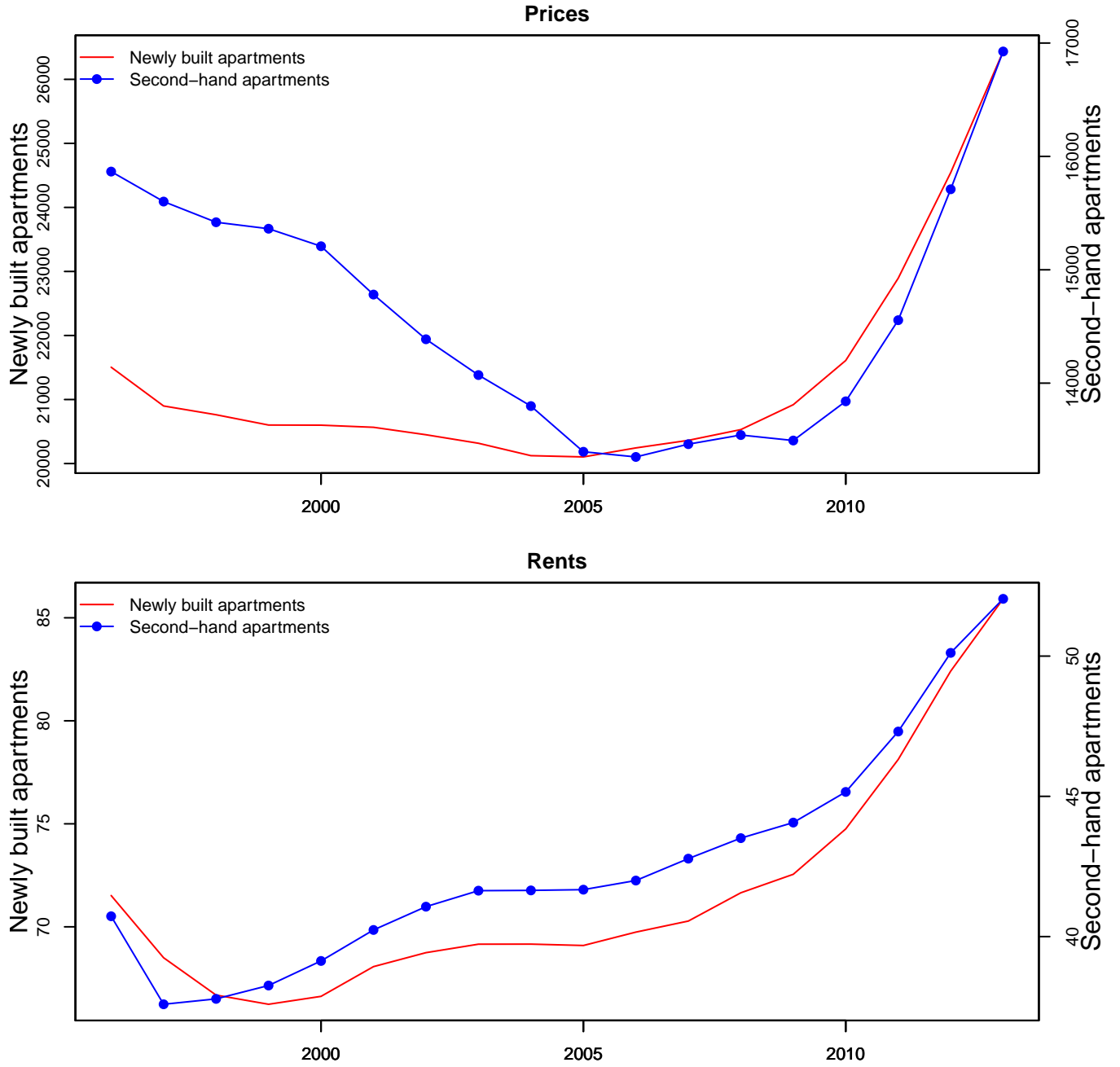


Figure 8: Chow test statistic of principal components of prices and rents

