UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

Graduate School

Master Thesis in Economics

Dynamics of the German housing market

Abstract

This paper examines the development of German housing prices in light of the recent price increase of approximately 27% since 2010. Following an asset price approach, the actual rent-price ratio is compared to a ratio that will be calculated based on fundamental values which, according to theory, explain housing prices. Variables include housing and rental prices as well as mortgage and interest rates. The second part consists of a cointegration analysis on quarterly data from 1980Q1 to 2018Q4 where I test if housing prices inhibit a long-term relationship with rental prices. While the first analysis finds that the house price increase is explained, the result of the cointegration test suggests no stable long-run relationship between housing and rental prices in Germany.

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1. Introduction

After a decade of subdued growth, Germany has experienced a sharp and ongoing increase in real housing prices since 2010 (Möbert, 2019). While various studies have proven that movements in residential property prices are often justified by fundamentals, the latest acceleration of the price increase and the ongoing public debate raise the question, if the market is overheated, and if prices are at unjustified levels. This thesis will investigate whether this price increase can be explained by fundamentals or whether prices are deviating from sustainable levels.

The housing market is a substantial part of a country’s economy. Changes in the value of the housing market can have a strong impact on national financial stability. Residential property is the dominant asset of most households, and in the case of tenancy, the monthly rent payments often present the largest share of household’s expenditures. Therefore, any variation in housing and or rental prices can impact private consumption. (Detzer et al.,2017; Glaeser and Gyourko, 2007) Many countries experienced a recession during 2007 and 2008, which was interlinked with the developments in the housing market (Voigtländer, 2013). Real estate prices which were extremely high before fell drastically, leading to major distortions in the overall economy (e.g. Spain). With this background, it becomes evident that the residential real estate market plays a substantial role and that it is crucial to understand movements in housing prices (Mikhed and Zemčík, 2009).

Fundamentals refer to parameters that arguably shift demand and supply of residential property. While there exists no final consent on which fundamentals influence demand and supply in the housing market, there is agreement that the user-cost for housing plays a substantial role (Gallin, 2008; Glaeser and Gyourko, 2007). For the purchase of residential property, the costs mainly include transaction costs, maintenance costs, and financing costs. For the alternative of renting an apartment, the aggregated rent payments represent the costs. Theory suggests that in an unregulated market, increasing purchase prices (costs) for residential property will lead to increasing demand for rental apartments. The equilibrium condition, i.e. the agent is indifferent between renting or purchasing, forces housing prices to correct downwards after substantial deviation. This interaction is captured by the price-rent ratio. According to theory housing prices tend to correct towards the equilibrium of the price-rent ratio; this property makes this ratio a popular tool to evaluate residential property prices (Campbell et al., 2009; Girouard et al. (2006); Hott and Monnin, 2008). In this context, the relationship between housing and rental prices was also subject to various studies, which investigated their long-run relationship with a cointegration model (Engsted and Pedersen, 2016; Gallin, 2008). According to theory, housing prices may deviate temporarily, but in the long run, prices will return to the long-run equilibrium.

This thesis uses an approach suggested by Girouard et al. (2006). In the study, the authors estimate the degree of overvaluation by comparing the actual price-rent ratio with a fundamental ratio for selected OECD countries covering yearly data from 1970 to 2003. The fundamental ratio is calculated based on mortgage rates, interest rates, and other cost components. Due to data issues, the authors do not derive a qualitative result for Germany. By ruling out any distortions arising from the dataset, this thesis will allow to estimate the degree of over/undervaluation of the price-rent ratio for Germany. For this purpose, I will use recent data from the OECD, covering quarterly data from 2003Q1 to 2018Q4. Furthermore, while Girouard et al. (2006) spread their interest on many countries, and hence generalize some parameters, I will look closely at the German housing and rental market, allowing to give a more sophisticated view.

In contrast to the vast literature on housing markets in the US, the German housing market has not been subject to many studies (Detzer et al., 2013). By filling the gap in the literature, and by eliminating the shortcomings of the reference paper of Girouard et al. (2006) the upcoming analysis should give a strong impression of the dynamics of the German housing market. Due to the widely unregulated market and other relevant housing market characteristics, the German residential housing market is especially suitable for analysis (Detzer et al., 2013; Voigtländer, 2013).

Using quarterly, national-level and seasonally adjusted, data from the OECD from 1990Q1 to 2018Q4, I will analyse the relationship of housing prices and fundamental variables. Based on the framework suggested by Girouard et al. (2006), I test if the price-rent ratio corresponds to the fundamental ratio, based on a calculation of the user cost of housing. The theory of the price-rent ratio assumes that housing and rental prices are cointegrated; In order to check this assumption, I will use the commonly used augmented Engle and Granger test (Engle and Granger, 1987; Gallin, 2003) in order to test if prices and rental prices are indeed cointegrated. If we find that the variables are truly cointegrated, the gap between those could serve as an indicator showing whether house prices are out of line of their long-term equilibrium value.

The thesis is structured in the following way: In chapter 2, a concise overview of relevant literature on the topic is given. Thereafter I will introduce to the substantial characteristics of the German housing market in chapter 3. Chapter 4 and 5 describe the data and methodology. The analysis of the price-rent ratio and the bivariate cointegration model are shown in chapter 6 and 7, respectively. After a discussion of the results and limitations in chapter 8, the conclusion is presented in chapter 9.

2. Literature review

The general debate about the run-up in housing prices is often associated with the presence of a "housing bubble". Research has addressed this topic controversy. According to Stiglitz (1990), a house price bubble arises when fundamentals do not explain the price growth. Accordingly, any price increase either might be explained by forces driven by economic fundamentals, or it might be that expectations about future price increases lead to a run-up in housing demand and prices. In their paper, Case and Shiller (2003) find that the serial correlation of housing prices in subsequent periods are hinting at a bubble. However, even if the terminology of a bubble might be misleading, it is undoubtedly right to consider expectations as an essential factor of decision making. By consuming a substantial amount of private savings, housing is not only considered to be a consumption good, but instead, it has also the character of a long-term investment (Case et. al, 2011; Detzer et al.,2007; Zemcik and Mikhed, 2007). Moreover, as an investment, the public expectation about future prices play an important role. If homebuyers expect increasing prices in the future, they are willing to pay prices which appear relatively high, because they expect that future price increases will compensate for their expenses (Case and Shiller, 2003). In the case of price depreciation, people will correct their expectations, not tolerating high prices any longer, which would lead to decreasing demand and price decreases.

Often rental prices and other fundamental variables like income are commonly assumed to be cointegrated with housing prices (Abraham and Hendershott, 1996; Capozza et al., 2002). However, across the researchers, there is no consensus on the impact of fundamentals. Using national-level data for the US covering 27 years, Gallin (2006) finds no evidence for cointegration between housing prices and rents. Zemcik and Mikhed (2007) use nationally aggregated data to investigate the movements of U.S. housing prices. They try to identify whether there are cointegration relationships between housing prices and fundamental variables like income, population, house rent, stock market and other variables. They find no relationship across fundamentals and housing prices.

The theory of the framework of the price-rent ratio follows that of the dividend-price ratio for stocks (Gallin, 2008). The price-rent ratio is an indicator widely used by investors in real estate markets to evaluate the profitability of investments in property. Private households get the first intuition whether it is better to buy or to rent housing. It is the ratio of the house price relative to the rent (i.e. income) that the property yields if it would be rented out for a year.

$$Price\ to\ Rent\ Ratio\ (PRR)\ =\ Real\ Estate\ Price\ /\ Annual\ Rent \qquad (1)$$

Inspired by the financial asset-pricing approach, some studies investigate whether rents and other fundamentals impact housing prices in such a way that inference about future price developments can be made. Gallin (2008) utilizes an error correction model on US data and finds evidence that the price-rent ratio has predictive power over future housing prices. Following the asset-pricing approach, Himmelberg et al. (2005) calculate the annual user cost of housing and compare it to actual levels. They find that prices are at sustainable levels according to their model. Investigating the housing market in London, Weeken (2004) finds that recent price increases are explained by decreasing interest rates. Looking at housing prices in California, US, Smith and Smith (2006) find that despite a significant price increase, housing prices correspond to their underlying fundamental values.

As housing is a highly heterogeneous good, it was subject to many studies which tried to identify socio-economic criteria of housing demand and supply. Investigating the American Housing Survey (AHS) Glaeser and Gyourko (2006) find that owner-occupied units and rental units in the US differ substantially in their characteristics. For instance, rural areas and big cities show considerable differences in both housing structure and population, i.e. there are significantly more homeowners in rural areas, then there are in cities. Furthermore, the authors estimate housing prices based on cost factors. They find that housing supply is greatly affected by local land use controls. Prices therefore are higher in areas where supply is regulated.

Due to the importance of housing price dynamics with respect to national and international stability, this research area has a well-established literature base. However, while most studies deal with the US housing market (Arshanapalli and Nelson, 2008; Zemcik and Mikhed, 2007; Meen, 2002), only a few investigate national European countries. Examples for studies on the German housing markets is the research by Voigtländer (2013) and Detzer et al. (2017). In their study, Detzer et al. (2017) find that unrestricted housing supply as well as the sophisticated financing system were the reasons for which the German housing market was unaffected by the recession in 2007/2008. Voigtländer (2013) studied the merits of the German housing market, by outlining particularities in comparison to other European countries. He finds great differences across preferences for buying and renting housing as well as in the overall housing market. The author concludes that Germans consider housing as being a consumption good, rather than an asset class. The prudential lending system and the sophisticated rental market are explanations for this observation.

3. The German real estate market

3.1. Housing market

As mentioned in the introduction, substantial price increases are observed in various European countries. Many studies deal with cross-country studies to identify commonalities. One disadvantage of these studies is that the regularities of national, domestic markets do not receive enough attention, which might consequently lead to inconclusive results (Engsted and Pedersen, 2016). In this context, looking at the German real estate market is especially advantageous, as it relatively less regulated (Detzer et al., 2013). While other countries, e.g. Sweden, are highly regulated, in the case of Germany, it can be assumed that demand and supply reflect actual market fundamentals/activities (Bergman and Sørensen, 2016). There are no rigid rules that would distort pricing in such a way that market power is undermined (Voigtländer, 2013). The following section presents necessary information on the properties of the real estate market and will outline how the market works.

In 2017 the national mortgage-dept to GDP ratio in Germany amounted up to 42%[1] (Destatis, 2019; Vdpresearch, 2019). This indicates the homeownership rates are relatively balanced in comparison to other countries with significantly higher rates, e.g. the UK (Kohl, 2015; Voigtländer, 2013). In this context, Germany proves to be a good choice for the subsequent investigation, as it shows a balanced distribution of rentals and homeownership. If either group were dominant, the relationship between rental prices and housing prices might be influenced.

The rate of homeownership is relatively low in Germany, 45% in 2016 (LBS, 2018). In comparison, Norway shows 80% of homeownership rate, Sweden 62%. The situation in the cities shows a more drastic trend; the homeownership ratio lies roughly around 20%. Considering this factual situation, the importance of a well-functioning market becomes apparent. Many studies describe the German rental market as sophisticated. Legislation balances the interest of landlords and tenants. However, legal regulation prevents rental prices from being raised arbitrarily. Accordingly, rent increases are limited to increase by 20% within a three-year window (Detzer et al., 2013). In addition, the rental control, which limits rent increases for new rentals to a maximum increase of 10%, has been introduced in bigger cities in 2015. The effect of this tool, however, is controversial not at least because landlords use loopholes to escape the regulations. While sharp price fluctuations are

[1] Own calculation based on numbers from Federal Statistical Office Germany and vdpResearch (2018).

counteracted with regulations, supply and demand are not regulated, i.e. every person can buy or rent any property available on the market, given that it can be afforded.

The lending system in Germany is relatively prudential. German investors and households are rather risk-averse, for instance, the favoured financing method, the building savings contract (Bausparvertrag), requires homebuyers to save much of the prospective housing price in advance before they get granted a loan. Mostly the applied mortgage rate is fixed with an average duration of 12 years combined with high down payments (Kohl, 2015; LBS, 2018; Voigtländer, 2013).

3.2. Development of prices and rents

Figure 1 shows that the series of the real house price (blue line) inhibits a cyclical pattern. After depreciation of the real housing prices, we see that previous price levels restore after a couple of years, but the second price correction took longer than the first.

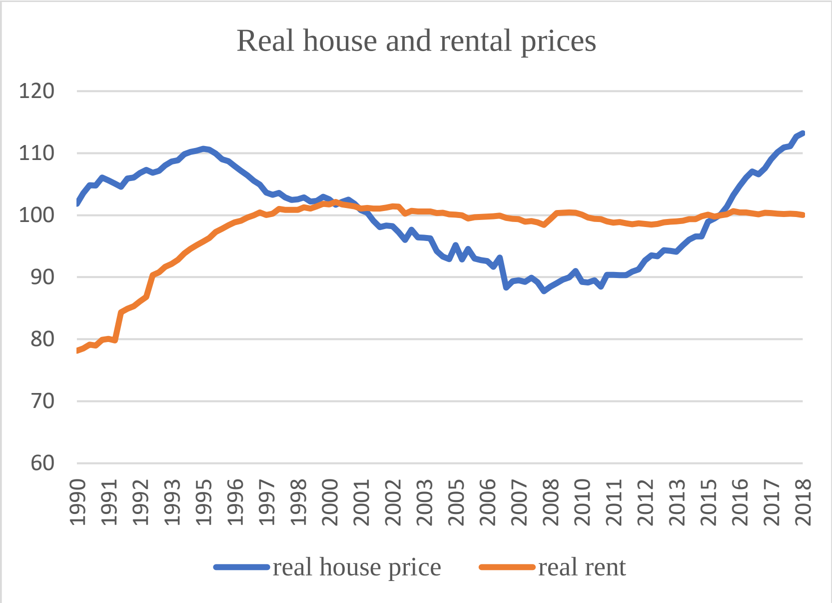

Figure 1: Real housing prices and real rental prices in Germany; index base year 2015

Another interesting observation is that real rental prices seem to be less volatile; in fact, they show a constant development since approximately 1996. In recent years we see that the real house price has increased by approximately 27%. It is noticeable that this price increase is relatively low compared to other economies in the EU, who saw more dramatic price increases (Detzer et al., 2013; IMF 2018). As Figure 1 shows, the financial crisis showed no impact on housing prices in Germany. According to research, the stability is mainly driven by the financing structure as well as the well-working rental market (Detzer et al.,2017; Voigtländer, 2013).

Theory suggests that rental prices are a fundamental factor of housing prices, which is why expectations are that increasing housing prices tend to correct towards the long-term average of the price-rent ratio (Gallin, 2008). Figure 2 shows the development of the price-rent ratio.

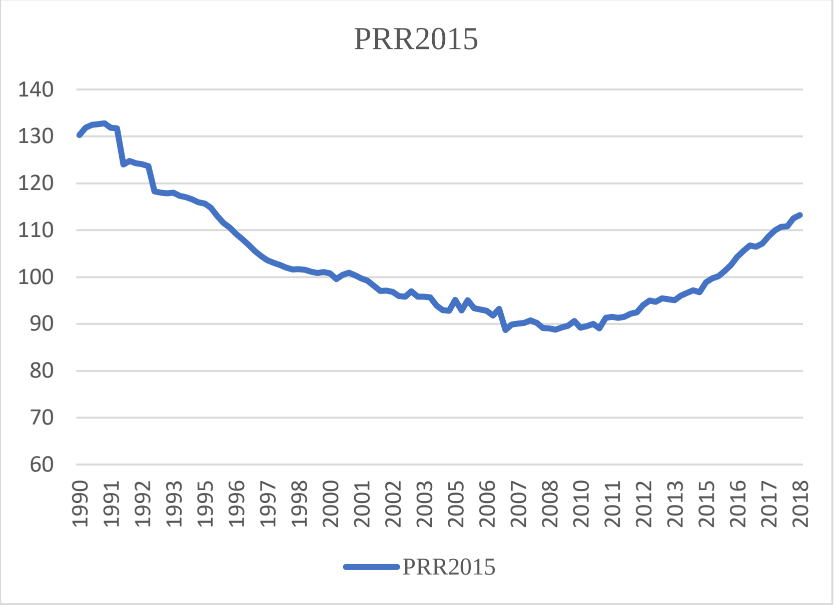

Figure 2: Price-rent ratio; index base year 2015

A clear downward trend until 2010 shows that the ratio decreased substantially by over 40% from 1990 to 2010. After 2010 the ratio shows a steadily increase. Due to the constant development of real rental prices, the price-rent ratio shows a similar trend like the house price series beginning in the year 2000.

In terms of over- or undervaluation, the overall impression is that neither the price series nor the price-rent ratio show significant inclines which exceed their long-term average. This might be a first hint that prices seem to be in line with fundamentals.

4. Data

For both parts of the analysis, I use quarterly data. For the comparison of the actual and the fundamental price-rent ratio (hereinafter referred to as PRR and F_PRR respectively), I use quarterly data from 2003Q1 to 2018Q4. The analysis of the long term cointegration relationship requires longer time-series, which is why I expand the time frame to begin in 1990Q1. Table 1 gives an overview of the sources and used manipulations on the variables.

Variable	**Source**	**Manipulation**
Average house price	Girouard et al. (2006)	Own calculation based on time series index. Prices correspond to average prices for a 70 m^2 apartment.
House price index	OECD time series	The House price index is based on nominal house price for the sale of existing and new buildings. The real series is deflated by the CPI and seasonally adjusted.
Interest rate	OECD time series	10-year government bond rate
Mortgage rate	ECB	Annualised agreed rate (AAR) / Narrowly defined effective rate (NDER), Credit and other institutions (MFI except MMFs and central banks) reporting sector
Deflator	OECD time series	I use the ratio of the nominal and the real house price indices
Price-rent ratio	OECD time series	The ratio is calculated by dividing the nominal house price index by the rent component of the consumer price index (Girouard et al., 2006).
Rent price index	OECD time series	The nominal index is given. I use the deflator, that is used for the house price indices to derive a real expression for the rental prices.
Actual price-rent ratio	Postbank Residential property survey (2018)	The PRR is calculated for over 400 cities across Germany, measuring the average purchase and rental prices for 70 m^2 apartments in 2017.

Table 1: Data sources and manipulation

5. Theoretical framework and methodology

This section outlines the theory and states the assumptions on which the analysis is based on. For the purpose of comparing the actual and the fundamental PRR as well as to identify a possible cointegration relationship between housing and rental prices, it is crucial to understand the underlying demand and supply framework.

5.1. Demand and supply in the housing market

In line with Gallin (2006), I will assume that housing supply depends on housing prices (P) construction costs (Z) and other supply shifters (θ_s).

$$Qs = S\,(P, Z, \theta_S) \qquad (1.1)$$

Income (Y), population (N), wealth (W), the user cost of housing (X) and other demand shifters θ_D form the demand function. The main

$$Q_d = D\,(Y, N, W, X, \theta_D) \qquad (1.2)$$

The user cost of housing (X) comprises the housing price (P) as well as cost components like the mortgage rate, tax rate, maintenance and depreciation as well as opportunity costs and expected capital gains (c).

$$X = P * c \qquad (1.3)$$

Rearranging equation 1.3, we can write the price (P) as a function of all other variables.

$$P = F\,(Z, Y, N, W, X, c, \theta S, \theta_D) \qquad (1.4)$$

In a frictionless market where any transaction costs are disregarded, we can assume that rents R must equal the user cost of housing (Gallin, 2008).

$$R = X = P * c \qquad (1.5)$$

According to equation 1.5, we assume that rental and housing prices are cointegrated. Building upon this assumption, the methodology I used to calculate the price-rent ratio (PRR) will be presented in the next section. In Chapter 7, I will test if there is indeed a cointegration relationship between housing and rental prices.

5.2. The user cost of housing

To be able to compare the purchase of housing with the alternative of renting, it is necessary to derive a functional comparison. It is essential to understand that not the house price itself is compared to the equivalent rent expenses, but all costs and expected gains from the ownership of housing must be taken into consideration before any inference can be made.

Possible tax deductions, as well as the opportunity cost of alternative investment, must be considered before the price-rent ratio can be assessed in terms of over- and undervaluation (Himmelberg et al., 2005).

Trying to find the relationship between the annual user cost of housing and the annual cost of renting, we must assume that in equilibrium, renters and landlords are indifferent between renting and owning. There is no option to gain excess return belonging to either group. The critical assumption here is the absence of arbitrage.

The method for the calculation of the user cost was first introduced by Poterba (1984,1992) and then further developed by others (Himmelberg et al., 2005; Girouard et al., 2006). Here I will replicate the method suggested by Girouard et al. (2006).

In equilibrium, the annual cost of homeownership must equal the annual rent payments R. In this case, any potential agent is indifferent whether to buy or to rent.

$$\mathrm{R} = \mathrm{P}*c \qquad \text{with} \qquad \mathrm{c} = \mathrm{ia}+\tau+\mathrm{f}-\pi \qquad (2.1)$$

With:

$$\mathrm{R} = \text{annual rent payments}$$

$$\mathrm{P} = \text{house price}$$

$$\mathrm{c} = \text{user cost of housing}$$

The user cost of housing comprises the actual cost of financing the investment as well as opportunity cost, which an alternative investment would have yielded.

$$\mathrm{C} = (\mathrm{ia}+\tau+\mathrm{f}-\pi) \qquad (2.2)$$

$$\mathrm{i}^{\mathrm{a}} = \mathrm{i}^{\mathrm{c}} + (\mathrm{m} - \mathrm{i}^{\mathrm{c}})\mathrm{e}^{-8\mathrm{r}} \qquad (2.3)$$

The first term in the brackets $\mathbf{i^a}$ captures the financing costs, as well as the opportunity cost of buying residential property. $\mathbf{i^c}$ is the after-tax-mortgage interest rate, and **m** denotes the mortgage rate. **r** stands for the interest rate which an alternative investment would cost, here it is the long-term interest rate and refers to government bonds maturing in ten years. (2.3)

$$\text{with } \mathrm{i}^{c} = \mathrm{m} - 0.53\ \mathrm{Min}\ (0.05, \frac{2556}{\mathrm{A\_HP}}) \qquad (2.4)$$

$\mathbf{i^c}$ is the after-tax nominal mortgage interest rate, which depends on the average house price **A_HP** and follows the deduction rule described in equation (2.4)[2,3]. For the calculation of the average house price, I take advantage of the data about nominal average housing prices given

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[2] This Equation follows Noord (2005) and Girouard et al. (2006).

[3] When considering tax relief (equation 4), it is important to distinguish between owner-occupied housing and residential property for rent. In Germany, landlords have the possibility to deduct interest expenses from the tax. After calculating the after-tax-mortgage rate, we see downward adjustments of approximately 33%.

in the study by Girouard et al. (2006). Using the index for nominal housing prices, and the given average prices for housing prices by Girouard et al. (2006) I calculate the corresponding housing prices for the whole time series from 2003Q1 to 2018Q4.

The property tax rate on houses is denoted $\boldsymbol{\tau}$ and fixed over the entire period. The tax rate I use will be fixed at 1% which reflects the average tax rate in Germany[4]. **f** denotes the recurring holding costs and captures the effects of depreciation, maintenance expenses and the risk premium that arises from holding residential property. The costs component **f** will be equal to 4% and constant. (This choice of numbers follows the example of Girouard et al. (2006)

Finally, $\boldsymbol{\pi}$ describes the expected capital gain or loss due to appreciation or depreciation, respectively. While Girouard et al. (2006) use a 5-year moving average of CPI, I will use the time-series of real housing prices.[5] Real housing prices reflect price development as well as changes in inflation. By calculating the average growth rate of real housing prices over a period of four quarters, I assume that potential house buyers form their expectations on the development of previous prices and inflation.

After rearranging equation (2.1):

$$\frac{\mathbf{P}}{\mathbf{R}} = \frac{\mathbf{1}}{\mathbf{i^a+\tau+f-\pi}} = \frac{\mathbf{1}}{\boldsymbol{c}} \qquad (2.5)$$

This expression is especially useful; we see the inverse of the cost equals the price-rent ratio. When the user cost increases, housing prices must adjust downwards so that the agent stays indifferent between buying and renting.

<u>Interpretation:</u>

Following Himmelberg et al. (2005) the term **c** can be expressed as yearly user cost in per cent per unit of house price, e.g. if the resulting user cost amounts to 4% and the house price is 100,000€ we have annual user costs of 4,000€.[6] Considering the inverse of the user cost provides the price-rent ratio, which allows us to compare the ratio to a baseline value to evaluate if prices are too high or too low compared to rental prices. Here the PRR amounts to 25, assuming no other differences between renting and buying, the agent should be indifferent between buying and paying 25 years of annual rent for the property or in other terms the house price amounts to 25 times the annual rent. A general rule states that buying is

[4] Usually tax rates differ across municipalities and range from x to x (source)
[5] The calculation of the expected capital gain follows the example of the approach used in Gallin (2006).
[6] For a detailed illustration see Himmelberg et al. (2005)

more favourable when the PRR is below 20. Over 20 buying property becomes relatively expensive compared to renting[7].

6. Analysis: Comparing the fundamental with the actual price-rent ratio

There are several options to compare the actual price-rent ratio PRR with the estimated fundamental ratio *F_PRR*. By comparing both indices (with the same base year), we can conclude the differences in the development of both time series. After deriving the time series of the fundamental PRR, we must transform it into an index based on the year (here 2015) the actual series has. To do so, I calculate the average of the PPR for all periods in 2015 (x). This number is set equal to 100. Now all other numbers are indexed following:

$$x = \frac{F\_PRR}{F\_PRR_{2015}} * 100$$

As the simple comparison only allows a limited insight a more promising way is to set the indices equal to the base year where the actual price-rent ratio is closest to its long-term average[8](Girouard et al., 2006). The theory behind this approach is that the PRR will adjust to its long-term average after short-run deviations.

In their paper, Girouard et al. refrain from calculating a long-term average value of the PRR for Germany, as their time series exhibits strong trend movements before 1990, which would distort the comparison. Instead, they simply set the series equal to an arbitrary base year. Consequently, this procedure does not allow to make any valuable inference. By limiting the timeframe for the calculation of the long-term average to comprise only values from 1990Q1 to 2018Q4, I will rule out that the results suffer from the mentioned distortions.

Another way is to try to convert the index of the price- rent ratio into a level variable, by using an actual level of the ratio. The distance between the actual and the fundamental price to rent ratio can then be interpreted as overvaluation/ undervaluation. For the baseline scenario, I will convert the actual PRR index to values, by using the average PRR for 2018 based on over 400 cities and municipalities.

[7]. This is according to various online sources like residential property guides etc.
[8] The Long-term average is calculated starting from 1990Q1- 2018Q4

Table 2: Illustration of calculation of the fundamental value of the PRR for Period 2016Q2

Variable	**Equation**	**Value**
Average house price in €	A_HP	149,225€
Mortgage rate in %	m	1.81%
After-tax mortgage rate in %	$i^c = m - 0.53\,\text{Min}(0.05, \frac{2556}{A\_HP})$	0.902%
Interest rate (10-year government bond rate)	r	0.08%
Total financing costs	$i^a = i^c + (m - i^c)e^{-8r}$	1.804%
Tax rate on property	T	1.00%
Other cost	F	4.00%
Gain or loss from property	Π	1.06%
User cost of housing	$c = i^a + \tau + f - \pi$	5.75%
P/R	c^{-1}	17.406

6.1. Index base year 2015 of actual and fundamental PRR

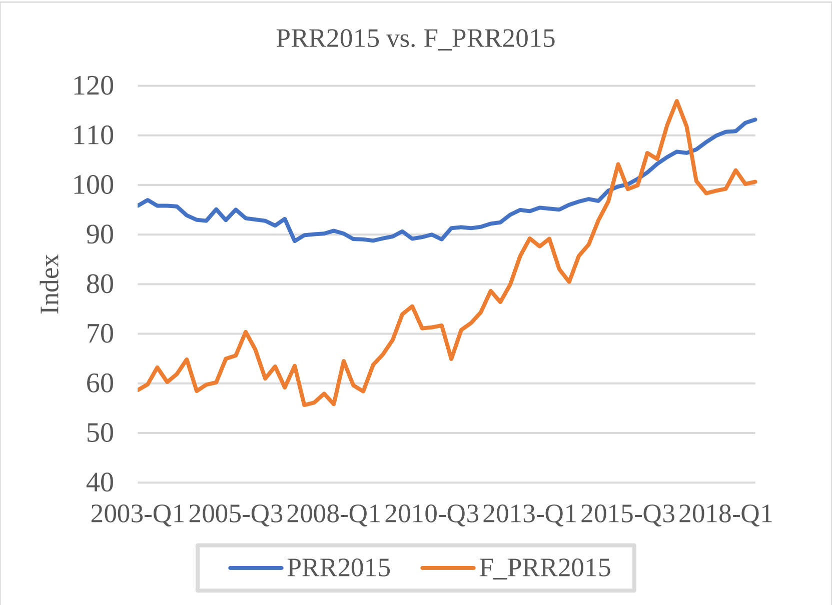

Figure 3: Index base year 2015 of actual and fundamental PRR

Figure 3 shows that PRR_{2015} has decreased until 2011, falling ten percentage points. Starting in 2010Q1, we see an incline of approximately 25%. An interesting finding is that we see, that both series seem to have similar trends over the observed time. While showing only subdued growth until 2011, both series start increasing after that. Indeed, the plot of the difference in the growth rates of PRR_{2015} and F_PRR_{2015} supports this view (Figure 8 and Figure 9 Appendix).

6.2. Long-term average

In order to calculate the long-term average, the data set is restricted to only contain observations from 1990Q1 to 2018Q4. Doing this, we exclude the periods before 1990, which distort the average because of the sharp decline. The long-term average amounts to 102.644, and the quarter where the actual PRR_{2015} is closest to this value is 2016Q1. Thus, we change the base year from (the average of) 2015 to be equal to 100 in 2016Q1 for both series.

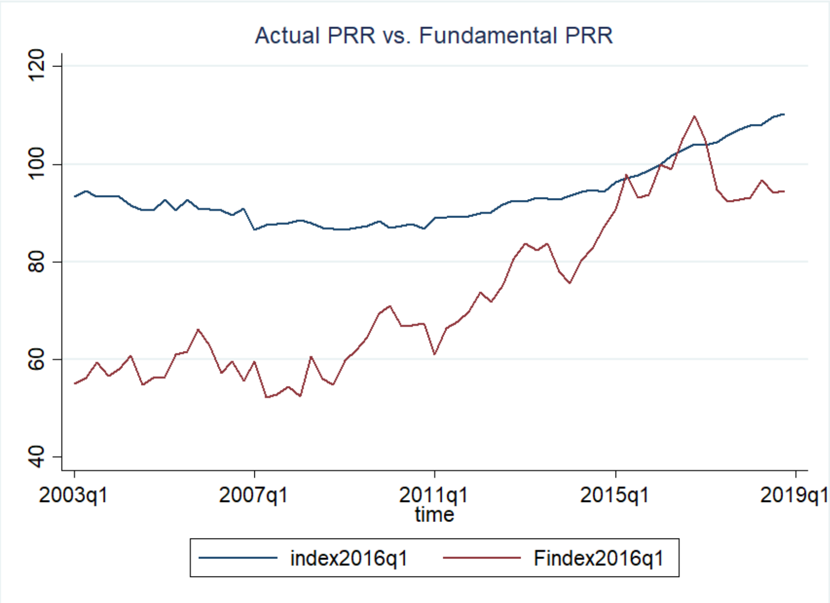

Figure 4: Long term average comparison of PRR¬2016 and F_PRR2016

According to the demand model shown in Chapter 5, demand has increased due to decreasing cost, induced by the strong decrease in interest rate. This is in line with the findings by many studies (e.g. Glaeser and Gyourko (2006); Zemcik and Mikhed, 2007).

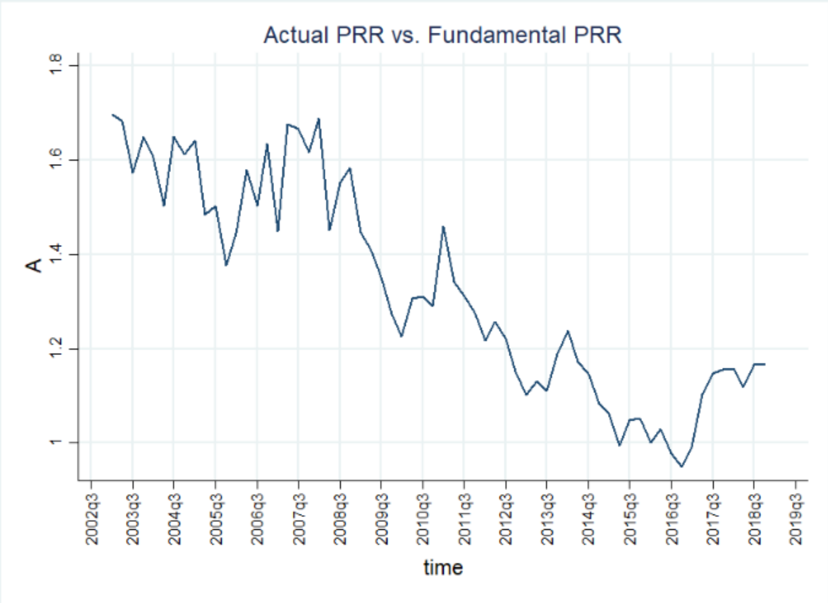

Figure 5: Growth rate differences of long-term average comparison of PRR¬2016 and F_PRR2016

Figure 4 and Figure 5 show that the fundamental PRR is smaller than the actual PRR for periods before 2010. The discrepancy, however, is not constant. While the actual PRR was more than 1.7 times as large as the fundamental PRR, the difference decreases steadily until the fundamental value even exceeds the actual PRR. In terms of under- and overvaluation, the actual PRR was too high in comparison to the fundamental ratio until approximately 2015. After a short phase of overlapping (i.e. the ratio of the actual and fundamental PRR close to 1 (Figure 4), one sees a stronger discrepancy again, indicating an overvaluation of approximately 20% from 2018Q1 ongoing. As the fundamental PRR calculates in levels, it allows us to transform the index into level variables, this would, of course, lead to the same outcome. Thus, we will take a closer look at the level comparison later in the next section.

6.3. Level comparison

To conduct a level comparison of both time series, we need to transform the index variables back to level variables. As the actual PRR_{2015} is only given as an index variable, I include a reference value from the Residential Property Survey (Postbank, 2018) to transform the series into a level variable. The average PRR[9], it amounts to approximately x=19.287 for 2017. Now, I generate a new variable setting the average in year 2017 of PRR_{2015} equal to x.

[9] The PRR is calculated for over 400 cities across Germany, measuring the average purchase and rental prices for 70 square meter apartments in 2017

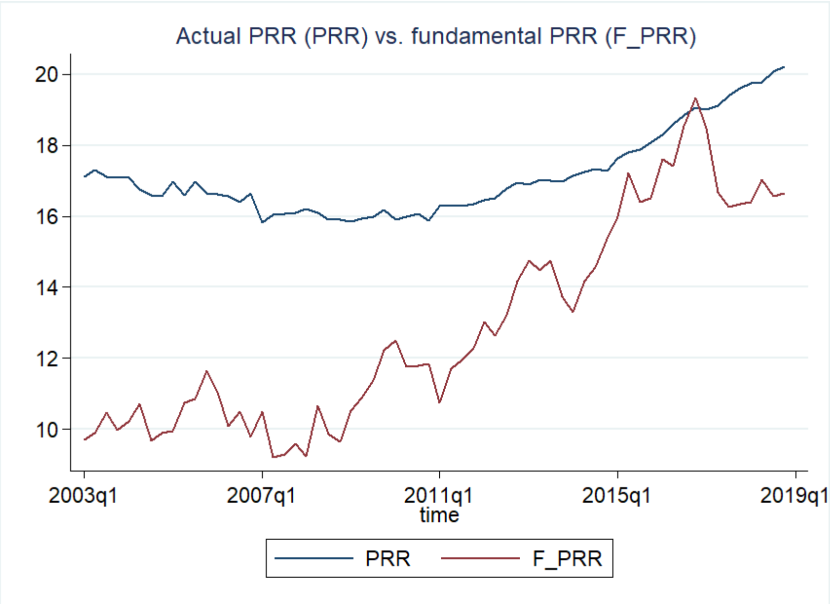

Figure 6: Level comparison of PRR¬2016 and F_PRR2016

As Figure 3 showed already, the level-display in Figure 6 reveals that the fundamental PRR has increased by over 80%.

Another interesting finding is that the long-term average approach yields very similar results compared to the actual level observed in the market. For quarter 2016Q1 we see a F_PRR of 17.608. The market value for that same period is 18.305, which corresponds to a deviation of approximately 4%. Thus, the general rule of treating the long-term average as a benchmark for equilibrium in the market seems justifiable.

Addressing the actual levels of the ratio, we see that the ratio lately shows values around 20 (2018). This is more than the long-term average, and therefore it can be interpreted as inflated pricing. Indeed, the recent discrepancy of the fundamental and the actual PRR show that the market might be overheated. While the long-lasting increase was justified by increasing fundamentals, the actual prices might now be decoupling and moving towards unsustainable levels.

All three ways of comparing the fundamental with the actual PRR indicate a substantial price increase of the fundamental value. Thus, it seems that the fundamentals explain the price increase we see in the actual ratio PRR. In terms of demand, this means that fundamentals seem to have risen, explaining the price increase. In fact, we see that most of the variation of F_PRR is explained by the movement of the interest rate (Figure 10 in the Appendix).

According to the demand model shown in Chapter 5, demand has increased due to decreasing cost, induced by the strong decrease in interest rate. This is in line with the findings by many studies (e.g. Glaeser and Gyourko (2006); Zemcik and Mikhed, 2007).

7. Bivariate cointegration model

A cointegration analysis helps to identify if there exists a long-term relationship between two or more time-series variables. This section will test the assumption made in Chapter 5, namely that housing prices and rental prices are cointegrated. For this, I will use the commonly used augmented Engle and Granger test (Engle and Granger, 1987; Gallin, 2003). As cointegration relationships capture the long-term behaviour of variables, I will expand the considered time span to include data starting in 1990Q1 until 2018Q4, covering 28 years.

7.1. Methodology

In order to establish a cointegration relationship, the considered variables must be stationary, i.e. the variables are each integrated of order d. A time series Y_t is said to be stationary when the probability distribution is constant over time, i.e. it inhibits a constant variation around its mean value. A stationary series shows a constant mean, constant variance and constant auto covariance over time (Luetkepohl, 2005; Engle and Granger, 1987; Gallin, 2003). There are many ways to verify if a time series is stationary, i.e. inhibits a unit root. Mostly the Augmented Dickey-Fuller (ADF) or the Eagle-Granger tests are applied; here I will use the ADF.

The test for unit root/stationarity with Augmented Dickey-Fuller test builds upon the following framework, including a time trend and a constant[10]:

With time trend and constant:

$$\Delta Y_t = \beta_0 + \mu_t + \delta Y_{t-1} + \gamma_1 \Delta Y_{t-1} + \cdots + \gamma_{p-1} \Delta Y_{t-p+1} + u_t$$

<u>Hypothesis:</u>

H0: Variable is not stationary/ exhibits unit root: $\delta = 0$

H1: Variable is stationary: $\delta > 0$

Before we can estimate the ADF, we must select the optimal lag length. The optimal leg length ensures that the standard errors are correctly specified and that the underlying model does not suffer from autocorrelation. In general, too many selected lags to reduce the

[10] The ADF test is run for all three possible specifications, to rule out any uncertainty arising from the model specification.

power of the test and lead to a loss of observations. (Cheung and Lai, 1995). In the case of too few lags, one might encounter the problem of biased parameters and standard errors due to autocorrelation, for instance.

It is most intuitive to test for the number of lags by using an AR(p) process, with p indicating the number of lagged values of the dependent variable used as regressors. Doing so, we can rule out autocorrelation by including all lagged values of the variables which are significant. However, it is better to use Information Criteria, as here the trade-off between more observations and the lack of fit is considered. Most commonly used Information Criteria (IC) are the Akaike Information Criterion (AIC) by Akaike (1973) and the Schwartz Bayesian Information Criterion (SBIC) Schwartz (1978). Schwartz is often found to be more accurate, as the estimates are more consistent in larger samples estimates (Luetkepohl, 2005). As the underlying dataset is not large, I will rely on the lag length that is suggested by the majority of the IC.

For multivariate time series regressions, the method requires to identify the rank of cointegration, that is finding out how many of the variables are cointegrated[11] However, as we are investigating a bivariate model, there can mostly be one cointegration relationship; hence, we can continue with the estimation of the cointegration equation. In order to derive the cointegration equation, a linear combination of the non-stationary variables is estimated.

$$\mathrm{Prices}_t = \beta_0 + \beta_1 \mathrm{Rents} + u_t \qquad \text{M1}$$

After that, we will have to verify that the linear combination is stationary, i.e. there is a long-term stable relationship. The way to this is to test whether the residuals are stationary. If they were stationary, it would mean that there is a constant factor across both time series, making them cointegrated.

7.2. Results

Table 3: Results for the Augmented Dickey-Fuller Test

	Level		**First Difference**		
Variable	Model (C,T,L)	ADF statistics	Model (C,T,L)	ADF statistics	Decision
price	(C,0,3)	-1.882**	(C,0,3)	-3.891***	I(1)***
	(C,T,3)	-0.605***	(C,T,3)	-4.533***	I(1)***

[11] For example a set of 5 Variables with two cointegration ranks would suggest that at least two combinations of the variables are cointegrated.

rent	(C,0,3)	-2.213**	(C,0,3)	-3.848***	I(1)***
	(C,T,3)	-0.992**	(C,T,3)	-4.329***	I(1)***

Table 3 shows that both variables are integrated of order I(1) at least at a significance level of 5%. While visual inspection of the time series might give the first impression of which model specification is to be used, misspecification cannot be avoided with total certainty; hence, I use different model specifications.

First, we have to estimate the linear combination of the non-stationary variables. After that, we will have to verify that the linear combination is stationary, i.e. there is a long-term stable relationship. Table 5 shows the output of the regression (M1).

Table 4: Regression output – cointegration analysis

	M1: Housing Prices (P)		**M2: Housing Prices (P)**	
Regressor	β	Standard error	β	Standard error
Rent	-0.424***	(0.116)	-0.184	(0.138)
qdate			-0.0687***	(0.023)
constant	141.2***	(11.32)	130.0***	(11.58)
N	115		115	
R^2	0.107		0.172	

Model 1 (M1) shows a negative, significant coefficient for real rental prices. Accordingly, a one-unit increase in rental prices leads to an average decline of -0.424 in housing price units. This is contradicting the theoretical model set up in chapter 5, where it is assumed that housing prices are increasing in rental prices. However, this regression is spurious as Model 2 (M2) indicates, and it neglects the serial correlation of the data. Including the time variable, the coefficient of real rental prices becomes insignificant, suggesting no relationship between housing and rental prices. However, for the purpose of the cointegration analysis, our variable of interest are the residuals. The question is whether the residuals are stationary or non-stationary. The residuals of Model 1 (M1) are shown in Figure 7.

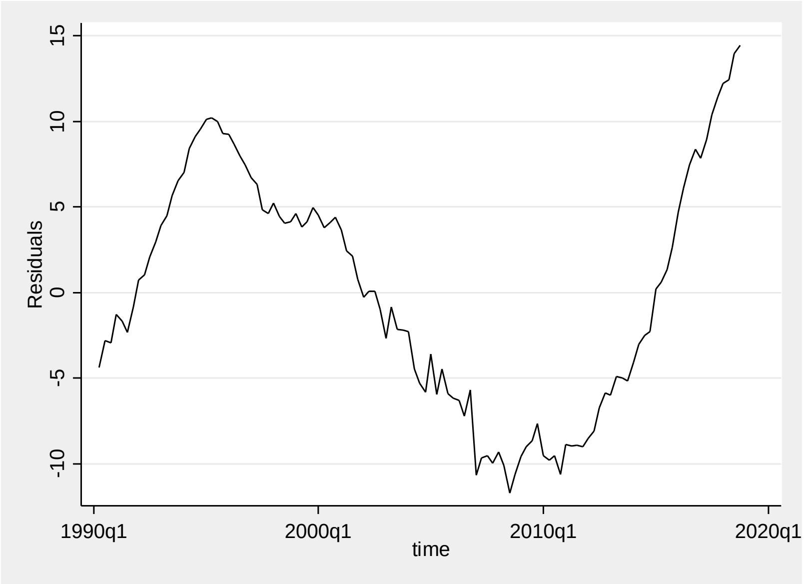

Figure 7: M1 residuals time series plot

We can interpret the estimated cointegration residual as follows: If there is a long-run relationship between housing prices and rental prices the residuals would show the deviation of this long-term relationship and the movements of the time series can thus be interpreted as the predicted correction towards the long-run equilibrium.

	Test Statistic	**1% Critical Value**	**5% Critical Value**	**10% Critical value**
(t)	0.317	3.994	3.390	3.082

Note: Critical values from MacKinnon (1990, 2010)

None of the critical values is exceeded, and thus the null hypothesis of non-stationarity cannot be rejected. In order to emphasise this outcome, Table xx shows the regression of first differences of prices on lagged values of the residuals. The non-significant estimates show that there is no long-run relationship between rent and housing prices and that there is no correction towards a long-run equilibrium, in other words, the residuals have no predictive power over housing price movements.

$$\mathrm{D.Prices}_t = \beta_0 + \beta_1 \mathrm{D.Rents} + \mathrm{L.u}_t + e_t$$

Table 5: First Differences Model

	M3: D. Housing Prices (P)	
Regressor	β	Standard error
D.Rent	0.161	0.155
L.residuals	-0.00590	0.0147
constant	0.0673	0.102
N	115	
R^2	0.010	

Note: Standard errors in parentheses* p<0.05, ** p<0.01, *** p<0.001

The finding of the cointegration test suggests that there is no relationship between housing and rental prices. This is in line with the findings of Zemcik and Mikhed (2007) who investigated the US housing market. Considering this finding, the next chapter will outline possible reasons for this finding as well as limitations to the study in general.

8. Limitations and Discussion

This section will discuss the findings in the context of possible limitations, that arise from the data and methodology.

Firstly, the data induces limitations to the validity of the method. Due to the small sample size, the cointegration analysis might suffer from small sample bias. Especially the significance of the Dickey-Fuller stationarity test might be distorted since the observed time span is too short. Another issue arises from the heterogeneity of the housing market. national-level data Housing prices not only differ significantly across regions but also within regions (Gallin, 2008; Voigtländer, 2013). It is essential to be aware of the average character of the PRR. While values around 20 are still considered justifiable in theory, there is a significant variation over different cities and municipalities. Especially big cities see actual ratios of over 30, clearly suggesting unreasonable price levels. Further research should focus more on panel cointegration test to rule out heterogeneity (Gallin, 2008).

Housing is a highly heterogeneous good; there are numerous characteristics which differ significantly across housing units. Next to the location of a property which might be the most apparent difference across housing units, it is crucial to understand that also other essential features of supply and demand differ. Socio-economic factors play a central role (Glaeser and Gyourko, 2006). One crucial aspect is the simplification and underlying assumption that owner-occupied housing units are comparable to rental units. On the one hand, owner-occupied houses are substantially bigger, and on the other, they also show structural differences in the location, i.e. rental units are closer to the urban areas while owner-occupied houses are located outside the city-centres. Glaeser and Gyourko, 2006).

Regarding demand functions for housing and rental units, it is also important to shed light on the population. Here empirical research suggests that the demand for housing comes from another population group than that for rental units. Furthermore, there are differences in the income structure and the overall utility function, so that the assumption of indifference becomes questionable (Gallin, 2008; Glaeser and Gyourko, 2006). The cointegration analysis conducted in chapter 4 supports this view. Hence the suggestion is that supply and demand on the housing and rental market build upon different conditions. The omission of important demand and supply shifters, i.e. omitted variable bias, could be a reason for the missing relationship between housing prices and rental prices.

Further limitation arises through the problem of omitted variables bias and the issue that key variables are challenging to measure. Due to this, conclusions about price over-/or undervaluation are not reliable. However, even if this study fails to evaluate the price development in terms of overvaluation, we still gain insight, to the role that financing costs, i.e. interest rates play.

In fact, Glaeser and Gyourko (2006) discuss their outcome, which showed a powerful impact of interest rates on the housing costs, too. They argue that construction costs which are arguably not attached to capital but to labour and material cost are likely to play a substantial role in this regard (Himmelberg et al.,2005). Findings by Shiller (2005, 2006) support this restriction, as they find no statistically significant impact of interest rates on housing prices over adequately long periods of time[12].

It is crucial to notice that the PRR is highly sensitive regarding a change of parameters. Variations in expectations about the future price growth (and other variables, as other research has shown) leads to high variations in the outcome.

Concluding from all mentioned limitations to the analysis and the results, this work should rather be regarded as having comparative value than to be a tool to evaluate price levels on the market.

[12] See appendix Table 6 and Table 7 for regression output.

9. Conclusion

The model suggests that the recent price increases are in line with fundamentals. Comparing the actual PRR to the estimated fundamental PRR showed that both time series show a similar growth pattern. These developments lead to a shrinking discrepancy between the actual and the fundamental PRR. Accordingly, the shrinking user cost of housing, mainly driven by continuously decreasing interest rates, play a substantial role in explaining the increase in housing prices. In fact, the PRR is highly dependent on the development of the long-term interest rate. The sharp decrease over the years has led to a situation where the purchase of residential property is highly lucrative. The comparison of the PPR suggests that the long-term average the market might be overheated. While the long-lasting increase was justified by increasing fundamentals, the actual prices might now be decoupling and moving towards unsustainable levels.

The cointegration analysis provided evidence that the housing and rental prices are not cointegrated, which is clearly contradicting the hypothesis that renting and homeownership are considered equal from an individual's perspective. Indeed, there are many socio-economic factors which play a substantial role in the decision making. Hence it seems justifiable to consider residential homeownership as a consumption good rather than an asset class. Following this logic, the fact that we couldn't confirm a cointegration relationship between rents and housing seems convenient. However, the applied methodologies might be biased due to data limitations. It is likely that our model suffers from small sample bias and omitted variable bias. Longer time period observation together with micro- and socio-economic data would be greatly beneficial for future work on this topic.

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11. Appendix

Checking the signs of the growth rates over one period (i.e. one quarter) shows a matching of approx. 53%. Over a yearly period, the share becomes approx. 64%. Thus, it seems that the actual PRR is affected by the factors which also impact the fundamental price-rent ratio.

Figure 8: Difference between the growth rates of PRR¬2015 and F_PRR2015

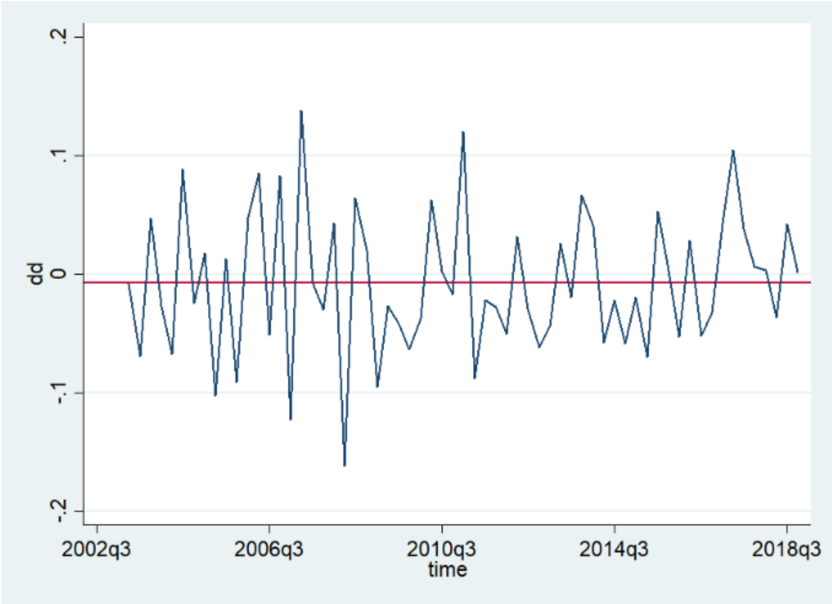


Figure 9: Density plot of the differences in growth rates of PRR¬2015 and F_PRR2015

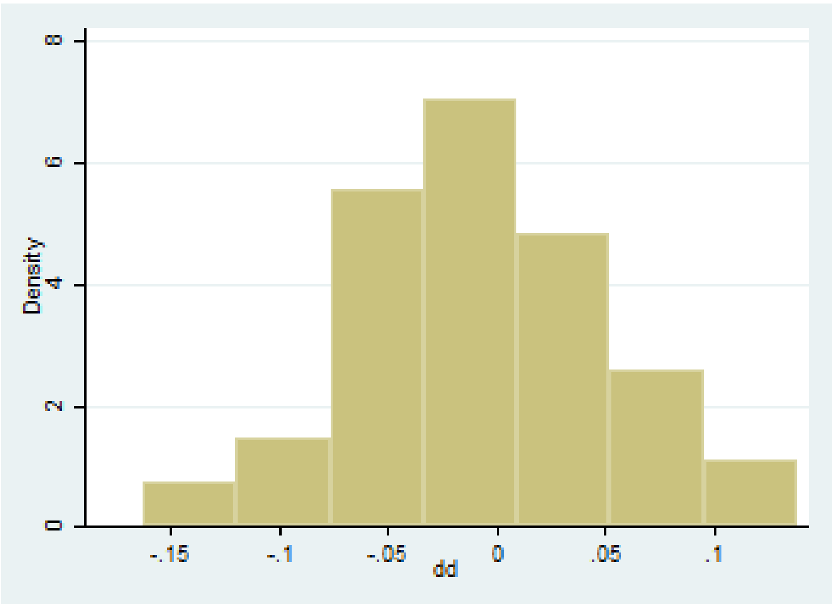
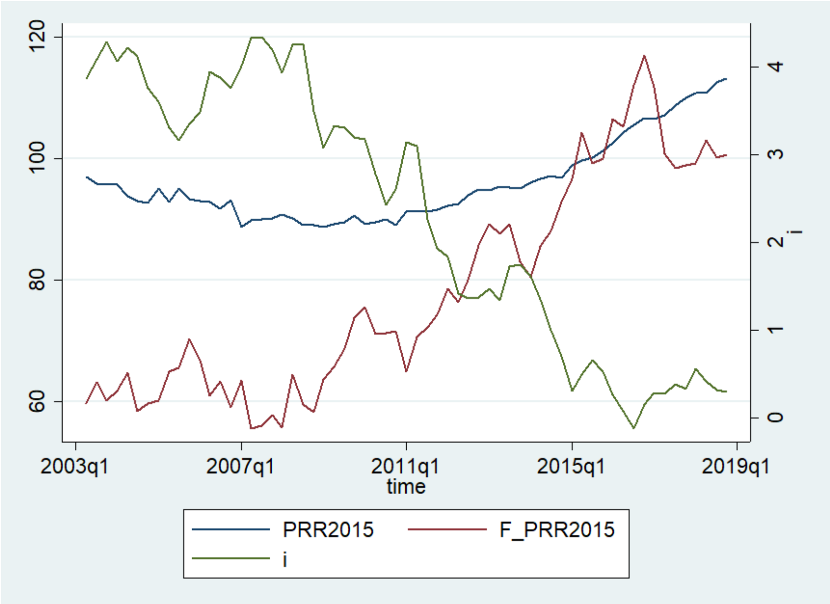


Figure 10: Timeseries of PRR2015 F_PRR2015 and interest rate



Regression output

Table 6: Real prices

	Real Housing Prices		***Real Rental Prices***	
Regressor	beta	Standard error	beta	Standard error
qdate	-0.0902	(0.0566)	-0.0433***	(0.00778)
interest	-6.980***	(0.989)	0.826***	(0.136)
constant	117.4***	(11.97)	108.9***	(1.645)
N	62		62	
R2	0.709		0.386	

* p<0.05, ** p<0.01, *** p<0.001

Table 7: Price-rent ratios

	PRR2015		***F_PRR2015***	
Regressor	beta	Standard error	beta	Standard error
qdate	-0.0494	(0.0532)	0.307***	(0.0688)
interest	6.196***	(0.929)	-10.89***	(1.200)
constant	109.0***	(11.24)	20.36	(14.53)
N	62		62	
R2	0.721		0.929	

* p<0.05, ** p<0.01, *** p<0.001