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EXPLAINING AND FORECASTING RESIDENTIAL RENTS
DETERMINATION OF IMPORTANT PARAMETERS BASED ON CORRELATION ANALYSIS

RESEARCH REPORT
APRIL 2018

REAL EXPERTS.
REAL VALUES.

Explaining and forecasting residential rents Determination of important parameters based on correlation analysis

In times of great market dynamic and increasingly intense competition, high performance systems are essential for analytical and decision-making purposes. Real Estate and Market Research is focussing on topics such as information gathering, key performance indicator analysis and forecasting as well as appraising potential. A decisive factor is the knowledge of relevant parameters relating to real estate market variables. This study shows methods and results of a parameter analysis as they relate to market rents as the dependent variable. The data is based on German residential property markets in cities with populations in excess of 70,000.

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01 | Starting point: requirement for models to explain and forecast market rents

The income generated by real estate portfolios is driven first and foremost by the rental incomes received. These can also influence potential and actual sale prices via the capitalised income value. The primary and most important parameter relating to the individual contractual rent is the assumed market rent for the location, property use type and building quality. This is both a benchmark for strategic portfolio management and controlling, but also of interest from an operational and tactical viewpoint, e.g. in the determination of the rent for vacant space, the formulation of contracts or the planning of transaction timings.

Historic market rents may be ascertained from market reports, data bases and own research activities. Future market rents, however, require a forecast. Even if this is always associated with a particular level of uncertainty, at least a certain level of knowledge with regard to growth rates and their bandwidth is helpful for future planning and decision-making processes. Relevant key indicators are often based on a particular submarket, as rents may develop at very different rates over the short, medium and longer term. This is not just relevant on an international comparison, but may also be a pertinent factor for smaller regions and individual use classes.

One example of a rental growth analysis in larger German cities is shown in the following chart, which demonstrates three statistical constellations: the minimum (Duisburg), median (Oldenburg) and maximum (Berlin):

RENTAL GROWTH RANGE

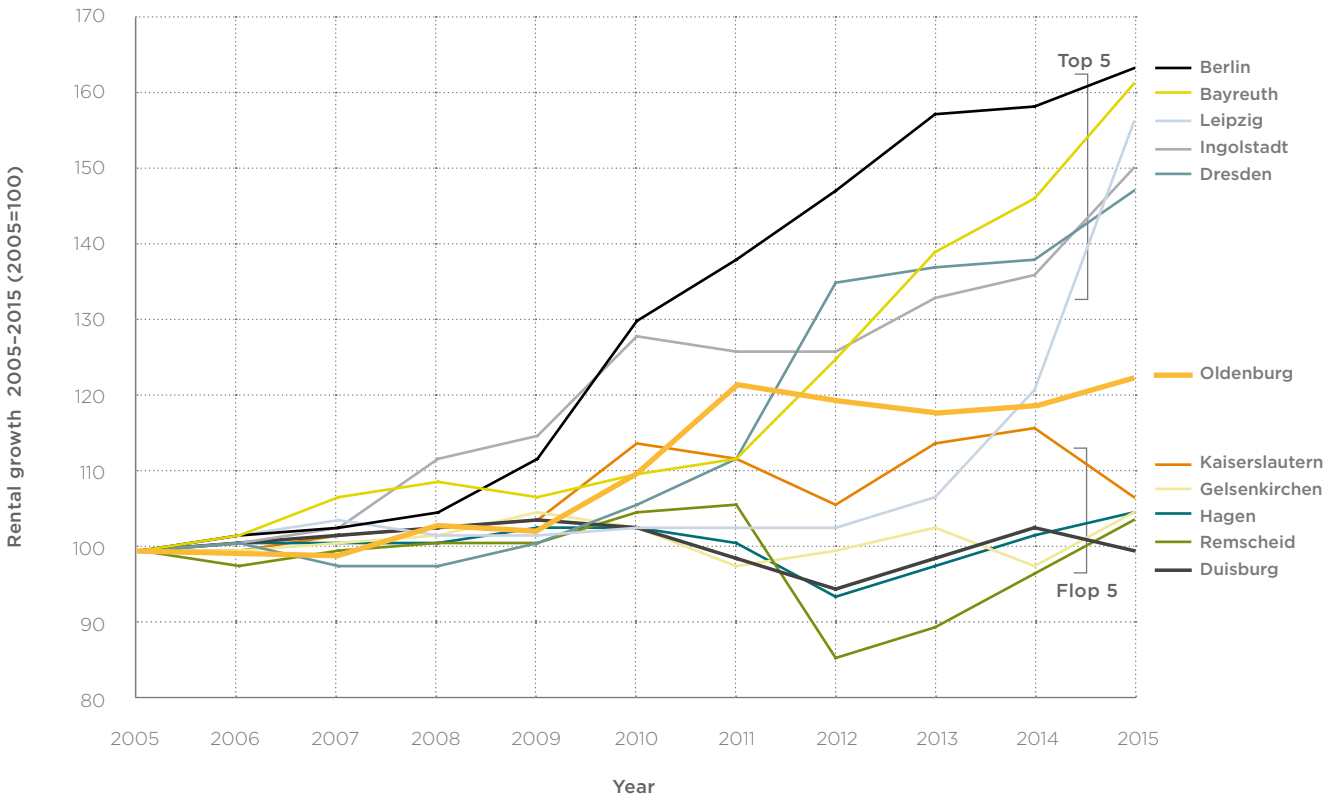

Figure 1: Rental growth range (residential rents in 11 German cities with populations in excess of 70,000, 2005 = 100)
Sources: Thomas Daily; own research

It can be observed that the growth rate is very uneven. After 10 years, some locations are at almost the same level as the starting point, whilst the forerunners have experienced over 60% growth. This is due to the varying market dynamic in the period under review. A number of cities were in the mid-range over the first few years, but then experienced very high rental growth and were positioned well ahead at the end of the period, for example the absolute forerunner Berlin.

When looking at the individual cities, there are some specific characteristics, which could explain this trend. One example is the dominance of the automotive sector in the city of Wolfsburg. However, this is not necessarily the case in other cities or across the entire sample. Qualitative explanations are barely relevant for the standardisation of market selection, risk analysis or portfolio management processes in order to process data, algorithms and interfaces for new digital applications. Even if manual estimates are still necessary in the case of real estate investments, most complex IT processes such as calculating key indicators, extrapolating trends, sorting and filtering will be automated in future, which requires generally accepted analytical and forecasting models.

A first important step in the development of market analysis and market forecasting models is the collection of relevant input parameters. The models based on these should focus on the important and actually relevant variables. The complexity and vulnerability of the overall model can also be controlled by limiting the number of parameters. The selection criteria for the parameters and data used are governed by the statistical and theoretical explanatory power of the variables and the performance level of the models.

02 | Findings of previous reports on parameters relating to residential rents

As part of this study we have, as an example, conducted an analysis of parameters affecting residential rents in the new-build sector. The selection of relevant factors is based amongst other things on previous research on international real estate markets. The number of factors was then gradually reduced by reference to exclusion criteria and data series tests. The objective is a list of relevant parameters relating to trends in residential rents as a reliable basis for further modelling.

The search for and assessment of parameters to explain real estate market trends have repeatedly been the subject of research into real estate economics. There has been much research over the last few years into the empirical market-related assessment of the correlation between determining variables and particular real estate economic-related parameters. Another line of research comprises concept works, for example on statistical econometric models based on specific forecasting techniques. We will briefly outline a few interesting examples below.

The long-term relationship between house price growth, per capita income, population trends and other indicators was the subject of a study by Gallin (2003). On the basis of data collected for 95 metropolitan regions in the USA over a period of 23 years, the report showed that the change in purchase prices for houses is only dependent to a limited degree on a change in the parameters under review, in particular income per capita. This finding was contrary to results of earlier studies, which had often stated that there was indeed a long-term equilibrium between house prices on the residential property market and key indicators.

The forecasting of rents in the retail sector in the UK was investigated by Tsolacos on the basis of a regression analysis in his study from

the year 1995. He came to the conclusion that particularly demand factors such as changes in GDP and consumer spending were relevant for the determination of future rental growth in the case of retail properties.

The identification of important determining factors for the growth of residential property values in Germany was the subject of a study by Westerheide and Dick in the year 2010. The authors identified parameters which could affect residential property value growth over the long-term. Factors driving increases in value included direct and indirect socio-economic effects, for example an increase in the number of private households or an increase in individual pension planning sourced from property, but also economic trends such as a growth in productivity and incomes. Opposing or dampening trends included for example increases in taxes and outgoings. One theory is that value growth is increasingly driven by qualitative and regional variations.

The Deutsche Bundesbank (German federal bank) analyses the situation on the German residential property market on the basis of its own model comprising financial market indicators (including private household borrowing and the volume of real estate lending by domestic banks), real economic indicators (for example investments in residential development and residential building contracts) and price-based indicators (residential property prices, the relationship between purchase prices and annual rents for condominium apartments etc.).

Maurer, Pitzer and Sebastian (2001) constructed a hedonic price index on the basis of transaction data on the Paris residential property market. The purpose of the hedonic analysis was the assessment of the heterogeneity of real estate markets. Analyses of the investment process could also be used to optimise the indices so constructed. However this type of model is heavily dependent on the quality of the data base, which makes a universal analysis more difficult to achieve.

Bohl, Michels and Oelgemöller (2011) also constructed a hedonic model in order to estimate the effect of various residential property factors on prices by the use of a regression analysis, in this case for the city of Münster. The result showed that prices were affected by factors such as age of the property and locational factors, but also the varying sizes of the properties.

Blaas and Wieser (2004) investigated residential rents on the Austrian property market and showed that subsidised residential construction had a negative influence on real market rental growth, resulting in both short and long-term effects. On the basis of an econometric analysis the authors also showed that there was a short-term effect on market rents mainly from the growth in the number of households and a long-term effect driven predominantly by building costs. They also concluded that incomes had a negligible effect on real market rental growth.

Möbert, Kortmann and Nemeth (2008) tested the effect of residential property characteristics and socio-demographic and macroeconomic location factors on rents via a hedonic regression model. Their analysis was based on over 27,000 apartments in 10 cities in the Ruhr region. It showed that variables relating to property characteristics often showed the expected explanatory power with regard to rental growth. By contrast, locational variables under investigation (proportion of minors, proportion of pensioners, proportion of persons in employment subject to social insurance contributions, proportion of foreigners, unemployment rate) appeared to have little effect. In the separated market for subsidised apartments, however, it appeared that property characteristics had virtually no significant effect on price levels.

Fritzsche and Kluge (2014) also investigated the effect of potential determinants on rent levels, in particular the divergence between eastern and western Germany. According to the study, important supply factors included vacancy, the size of apartments in terms of residential space compared to the land use for housing and infrastructure of the area in question and the year of construction of the property under review. Important demand side factors affecting rent levels included per capita disposable income, the increase in population and age-related factors. It is interesting that the variables under review have different effects in eastern and western Germany. Higher disposable income, for example, results in rental growth in western Germany, but this has so far not been proven to be true in the new German states. Vacancy rates, however, have a negative effect on rent levels in both eastern and western Germany, but this is significantly more pronounced in eastern Germany. The authors concluded there is no linear effect of vacancy rates on rent levels, but that any effects are much greater in excess of a critical mass.

The following table shows the results of the studies to date:

STUDY/ARTICLE	CORRELATIONS UNDER INVESTIGATION
Blaas, Wieser, Einfluss von Wohnbauförderung und Richtwertsystem auf die Mietenentwicklung, 2004	Residential rents, subsidised residential construction, various other factors (Austria)
Bohl, Michels, Oelgemöller, Determinanten von Wohnimmobilienpreisen: Das Beispiel der Stadt Münster, 2011	Residential property prices in Münster, location, age etc. (Germany)
Deutsche Bundesbank, Indikatorensystem Wohnimmobilienmarkt, Abruf 2018	Situation on the residential property market, various indicators (Germany)
Fritzsche, Kluge, Wodurch werden die Mietpreise bestimmt? Unterschiede in den Mieten in Ost- und Westdeutschland, 2014	Rent levels in eastern and western Germany, vacancy, residential density, year of construction, disposable income etc. (Germany)
Gallin, The Long-Run Relationship between House Prices and Income, 2003	House prices, per capita income, population etc. (US metropolitan regions)
Gallin, The Long-Run Relationship between House Prices and Rents, 2004	House prices and rents (USA)
Henger, Mieten und Einkommen gehen meist Hand in Hand, 2016	Residential rent levels, income (Germany)
Maurer, Pitzer, Sebastian, Konstruktion transaktionsbasierter Immobilienindizes, 2001	Hedonic price index, residential rents in Paris, characteristic factors such as location, size, fit-out (France)
Möbert, Kortmann, Nemeth, Hedonische Regression der Wohnungsmietpreise unter Berücksichtigung von Lagevariablen am Beispiel eines Bestands im Ruhrgebiet, 2008	Rent levels in the Ruhr region, apartment characteristics, socio-demographic factors, macroeconomic variables (Germany)
OECD, Recent House Price Developments: The Role of Fundamentals, 2005	House prices, various factors including population development and interest rates (18 OECD countries)
Sirmans, MacDonald, Macpherson, Zietz, The Value of Housing Characteristics: A Meta Analysis, 2006	House prices, characteristic fit-out factors (USA)
Taltavull de la Paz, Determinants of housing prices in Spanish cities, 2003	House prices, population growth, economic structure etc. (Spain)
Tsolacos, An Econometric Model of Retail Rents in the United Kingdom, 1995	Retail rents, GDP, consumer spending (UK)
Westerheide, Dick, Determinanten für die langfristige Wertentwicklung von Wohnimmobilien, 2010	Residential property values, demographics, distribution effects etc. (Germany)
Wheaton, Nechayev, The 1998–2005 Housing "Bubble" and the Current "Correction": What's Different This Time?, 2008	House prices, various indicators such as population growth and income (USA)

Figure 2: Selection of previous studies on the parameters affecting prices and rents
Source: own sample collection from report data bases and archives

Empira's previous research has also been based on the analysis of factors. One previous study (Q4/2017) investigated the prioritisation of residential property markets based on the parameter economic strength. The study analysed the correlation between regional GDP per capita and rent levels in the new-build segment in a city.

The starting point of the Empira study was based on theories relating to the correlation between the economic strength of a city and its rent levels. The data sample investigation comprised 80 German cities with populations in excess of 75,000.

The result was a basic correlation between GDP and rents (Figure 3). Of particular note were a few statistical outliers such as the city of Wolfsburg (rent around €9/m²/month; per capita GDP around €110k) and Ludwigshafen am Rhein (€9/m²/month; €82k), which showed very moderate rents compared to the respective GDPs. By contrast, there are very expensive cities in the residential property market compared to per capita GDP such as Munich (>€15/m²/month; €72k) and Berlin (>€10/m²/month; €35k), at least in the new-build segment. It was also noticeable that not all structurally weaker locations are necessarily characterised by very low rent levels.

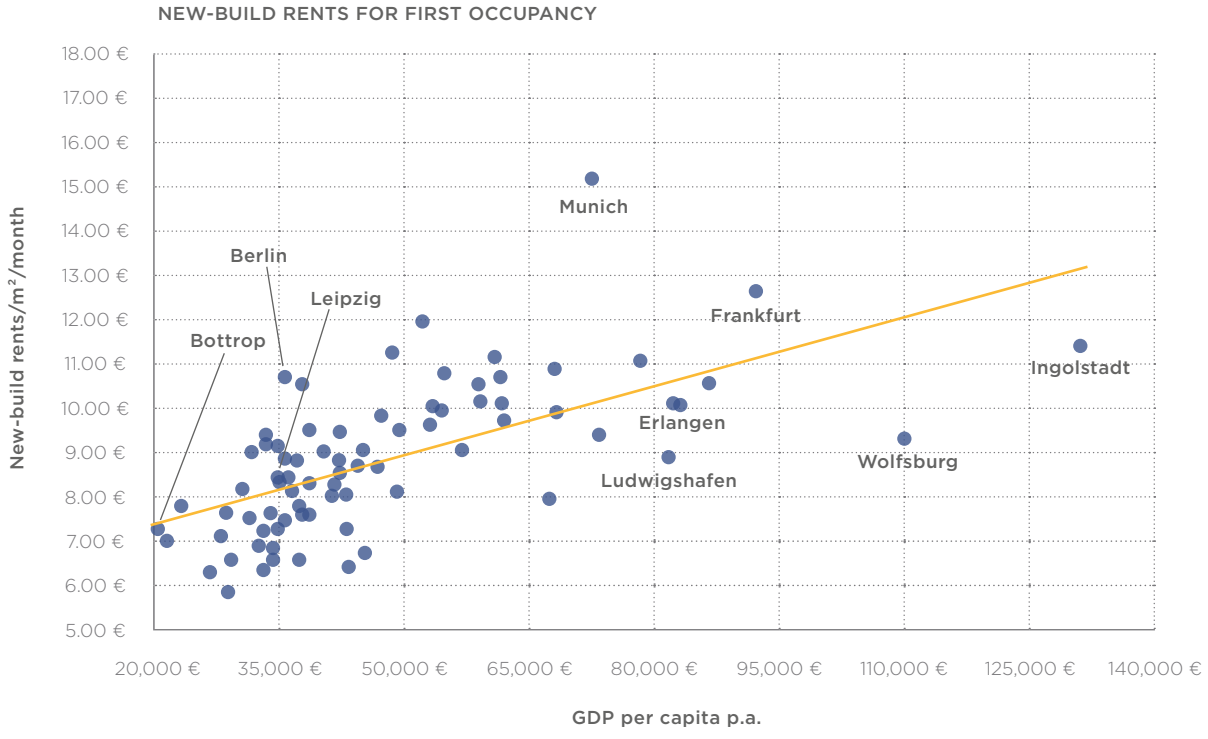

Figure 3: Relationship between GDP and rents (constructed since 2000, high specification), German cities, data 2015
Sources: Federal Statistical Office, State Statistical Offices, Thomas Daily

The phases of the analysis included filtering and sorting information and data. The first evaluation of the various locations regarding their price level was made on the basis of the relationship between rent levels (converted into space per capita and annual rent) and economic strength. The conversion makes no difference to the ranking, but these synthetic indicators allow a better interpretation of the correlation between supply and demand. Please see Figure 4 for a summary of the resulting ranking.

LOCATION	INDICATORS 2005			INDICATORS 2015			CHANGE 2005 – 2015		
	GDP € PER CAPITA P.A.	RENT €/M² P.M.	RELATION GDP/RENT	GDP € PER CAPITA P.A.	RENT €/M² P.M.	RELATION GDP/RENT	GDP € PER CAPITA P.A.	RENT €/M² P.M.	RELATION GDP/RENT
Ingolstadt	**65,214**	**7.56**	**15.97**	**131,569**	**11.33**	**21.50**	**+102%**	**+50%**	**+35%**
Dessau-Rosslau	20,329	5.46	6.89	28,482	5.92	8.91	+40%	+8%	+29%
Remscheid	27,779	7.01	7.34	34,519	7.28	8.78	+24%	+4%	+20%
Kaisers-lautern	35,352	6.27	10.44	45,310	6.72	12.49	+28%	+7%	+20%
Aachen	26,898	7.56	6.59	35,248	8.31	7.85	+31%	+10%	+19%
Bremer-haven	29,174	5.42	9.97	33,902	7.59	8.27	+16%	+40%	–17%
Hanover	49,780	6.52	14.14	57,084	9.04	11.69	+15%	+39%	–17%
Berlin	**26,761**	**6.58**	**7.53**	**35,428**	**10.73**	**6.11**	**+32%**	**+63%**	**–19%**
Dresden	32,168	5.96	10.00	37,153	8.79	7.83	+15%	+47%	–22%
Offenbach am Main	**37,214**	**7.90**	**8.72**	**37,493**	**10.51**	**6.61**	**+1%**	**+33%**	**–24%**

Figure 4: Relationship between GDP and rents (constructed since 2000, high specification), larger German cities, data 2005 – 2015
Sources: Federal Statistical Office, State Statistical Offices, Thomas Daily

It can be seen that there are some significant differences in the development of the relationship between per capita GDP and rents. Whilst the strongest 10-year growth in this indicator was in Ingolstadt with +35%, Offenbach am Main was placed last in this sample. Whereas the underlying rents had grown by 33% over the same period, the per capita GDP remained at almost exactly the same level, which produced a fall in the GDP/rent relationship of 24%. It is also noticeable that locations where the GDP/rent relationship fell significantly over the period under review are not necessarily characterised by poor economic growth as an underlying rationale.

It is not only the overall economic growth but also the changes in the relationship between GDP and rent levels from which it is possible to make initial deductions relating to market overheating, shortfalls and potential. In particular for cities where there has been a growth in the GDP/rent relationship, there appears to be a certain degree of catch-up potential in terms of rent levels. Locations where rents have not kept up with economic growth should be targeted by investors and closely analysed in terms of underlying causes and opportunities.

This and further research reports are available to view and download on the Empira website at www.empira.ch/en/company .

03 | City data and comparisons on a federal level as focus for this report

The research studies mentioned are broad, but also highly specific. They identify relevant parameters for the individual submarkets under review. It is apparent that the results are different in terms of regional, chronological and geographical focus. As far as we are aware there are currently hardly any comprehensive investigations into parameters affecting residential rents in German cities. The research by Empira is intended to provide an ongoing contribution in this regard. It is intended to establish factors, which have (statistically) verifiable effects on rental growth.

The current investigation is based on various data series comprising corresponding indicators, which may be regarded as potential parameters affecting real estate markets. These are analysed to assess their correlation with rents. The analysis comprises key data on a federal level and various data series on a total of 80 German cities with populations in excess of 70,000.

The selection of the data used as the basis for this study has been made by the use of theoretical hypotheses relating to potential parameters affecting rental growth and also on the basis of the results of previous research reports. The final selection of indicators and particularly the period of the data series used for the analysis is in some cases limited by the lack of availability of pertinent data sources. In order to analyse a consistent data stream, we have made reference to official statistical data, but this is often compromised by the delay in publication of (potentially) relevant information. The above hypotheses and limitations have resulted in the selection of the supply and demand indicators listed in Figure 5.

The analysis of the sample of 80 larger cities includes data series since the year 2003. The growth rates over 10-year periods were analysed in terms of their correlation (e.g. the relationship of population growth in the period 2005 - 2015 to rental growth in the period 2005 - 2015). This procedure is based on the one hand on the assumption that this period represents a typical investment horizon on the property market and on the other hand that it is possible to generate sufficient

data points to provide a correlation analysis of the sample on a city level. The dependent variable in the investigation is the rent for new-build properties (€/m², apartment size 60 m² – 80 m², constructed since 2000, high specification fit-out).

At a national level, it was possible to utilise longer data series, mostly back to the year 1995. The respective analyses are based on year-on-year growth rates and the resulting data series were used as the basis for the correlation analysis. The endogenous factor is the annual growth rate shown in the rent index provided by the Federal Statistical Office (base year 2010 = 100).

INDICATOR	SOURCE	DATA SERIES
Population	Federal Statistical Office, State Statistical Offices, VGR der Länder (regional accounts)	Germany: 1995–2015 City: 2003–2015
GDP (current prices)	Federal Statistical Office, State Statistical Offices, VGR der Länder (regional accounts)	Germany: 1995–2015 City: 2003–2015
GDP/capita	Federal Statistical Office, State Statistical Offices, VGR der Länder (regional accounts)	Germany: 1995–2015 City: 2003–2015
Disposable income of private households/capita	Federal Statistical Office, State Statistical Offices, VGR der Länder (regional accounts)	Germany: 1995–2015 City: 2003–2015
Gross salaries/employee (domestic concept)	Federal Statistical Office, State Statistical Offices, VGR der Länder (regional accounts)	Germany: 2000–2015 City: 2003–2015
No. of persons in employment (by place of residence)	Federal Statistical Office, State Statistical Offices, VGR der Länder (regional accounts)	Germany: 1995–2015 City: 2003–2015
Unemployment rate (based on all civilians of working age, annualised average)	Federal Statistical Office, State Statistical Offices, VGR der Länder (regional accounts), Federal Employment Agency	Germany: 1995–2015 City: 2003–2015
No. of new building permits for apartments in multi-family apartment buildings (at city level per 1,000 inhabitants)	Federal Statistical Office, State Statistical Offices, VGR der Länder (regional accounts)	Germany: 1995-2015 City: 2003-2015
No. of completions of apartments in multi-family apartment buildings (at city level per 1,000 inhabitants)	Federal Statistical Office, State Statistical Offices, VGR der Länder (regional accounts)	Germany: 1995–2015 City: 2003–2015
Space completed in multi-family apartment buildings (at city level per 1,000 inhabitants)	State Statistical Offices, VGR der Länder (regional accounts)	City: 2003–2015
Purchase prices for condominium apartments (60 m² - 80 m², constructed since 2000, high specification fit-out)	Thomas Daily	City: 2004–2015
Vacancy rate for apartments	Statista	Germany: 2001–2015
House price index (base year 2015 = 100)	Federal Statistical Office	Germany: 2000–2015
CPI (base year 2010 = 100)	Federal Statistical Office	Germany: 1995–2015
Rents in the new-build segment (60 m² - 80 m², constructed since 2000, high specification fit-out)	Thomas Daily	City: 2005–2016
Rent index (base year 2010 = 100)	Federal Statistical Office	Germany: 1995–2017

Figure 5: Selected indicators
Source: own data collection

04 | Determination of relevant parameters based on correlation analysis

The interdependency between two or more parameters can be determined with the aid of correlation analysis (and also covariance and regression). The correlation coefficient shows the type and strength of the correlation in the range from -1 to +1.

One preceding key figure is the covariance. It also shows the occurrence of linear relationships between two (metrically scaled) parameters, but can include a much larger and unrestricted range of values. In arithmetical terms covariance is calculated on the basis of empirical observations, e.g. from two time series. It is necessary to calculate this by reference to identical units (e.g. monetary units or yield percentages). Covariance represents the mean of the aggregated and multiplied deviations from the respective mean of the data being analysed.

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$$cov(x,y) = \frac{1}{T-1} \sum_{t=1}^{T} (x_t - \bar{x})(y_t - \bar{y})$$

with:

$cov(x,y)$ = covariance of variables x and y
x_t, y_t = various values of x and y
$\bar{x}, \bar{y}$ = average of parameter values of x and y
T = number of parameter values/occurrences

Figure 6: Calculation of covariance
Source: own graphic, based on von Auer, Ökonometrie, 2007, p. 44

As covariances are difficult to interpret, the interdependency is often presented in terms of correlation coefficients. On account of its standardised range (-1 to +1), it is independent of the respective unit of measurement of the data. The correlation coefficient is calculated from the covariance by dividing the standard deviations of the respective indicators.

$$cor(x,y) = \frac{cov(x,y)}{\sigma(x) * \sigma(y)}$$

with:

$cor(x,y)$ = correlation coefficient of variables x and y
$cov(x,y)$ = covariance of variables x and y
$\sigma(x), \sigma(y)$ = standard deviation of x and y

Figure 7: Calculation of the correlation coefficient
Source: own graphic, based on von Auer, Ökonometrie, 2007, p. 45

Both statistical indicators have in common that strong positive values show a linear interdependency of the indicators, whilst significant negative values point to inverse interdependency. If there is an overall independence between the parameters, then the covariance and correlation values will be around the zero mark.

The degree of the correlation coefficient shows the respective strength and relationship – same or inverse direction – of the interdependency, but without giving an indication whether there is actually a causal relationship between the variables. Values around +1 show an (almost) perfect positive correlation and values around -1 show an (almost) perfect negative correlation. The aforementioned constellations are shown in the following graphic:

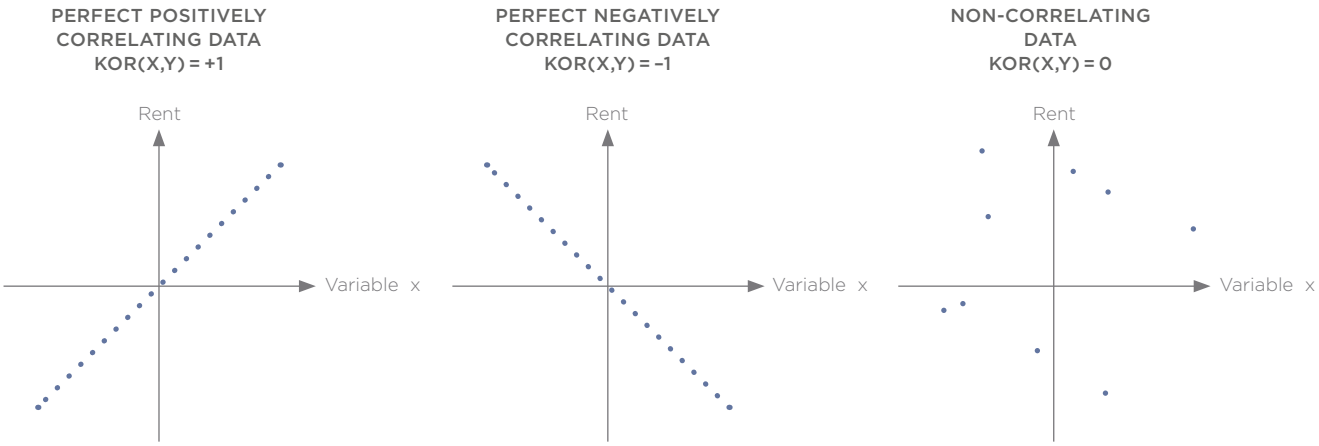


Figure 8: Correlation of two parameters in terms of different correlation coefficients
Source: own graphic

The more the correlation coefficient approaches the boundaries of the respective value range, the greater the likelihood of a statistically significant correlation of the two parameters. By contrast a correlation coefficient of or close to zero shows non-linear correlating parameters or those for which there is only a very weak (insignificant) linear correlation (Wooldridge, 2003, pp. 712-714).

The correlation analysis is verified by the calculation of the statistical significance. This process assesses the preliminary correlation by hypothesis testing. In doing so, the underlying null hypothesis states that there is no correlation between rents and the respective parameter. The null hypothesis is tested by calculating the p-value. If the p-value is below a certain significance level, then the null hypothesis can be rejected. The converse would indicate a statistical correlation between rents and the respective parameter (alternative hypothesis). The degree of statistical significance is dependent on various factors such as for example the sample size (Verbeek, 2000, p. 30).

05 | Determination of relevant chronological factors on the basis of time lag analyses

In addition to the synchronous analysis of the respective growth rates, time lags were also tested for their impact (city level: max. 2 years, national level: max. 4 years), in order to identify any possible up-front effects, which do affect rental growth after a certain delay (e.g. growth in GDP/capita 2013 vs 2003 compared to the rental growth 2015 vs 2005 = delay of 2 years).

The reason for this is that positive economic trends in a region (GDP growth or GDP/capita) are generally followed by an increase in employment numbers and incomes. One theory relating to this is that an improved economic environment tends to result in increasing rents, as rising purchasing power causes rising competition on the demand side. The above effects tend to appear after a time delay due to existing lease terms, time spent property hunting and market participants' decision-making processes, which means that a direct effect in the same time period cannot necessarily be assumed.

Supply side effects on rents are also subject to time lags in the market. As a basic principle, a significant increase in supply of residential space should weaken rental growth on the residential market. Indicators such as new building permits and completions usually happen in advance of rental growth, as market participants only experience and react to a change in market situation after a time delay.

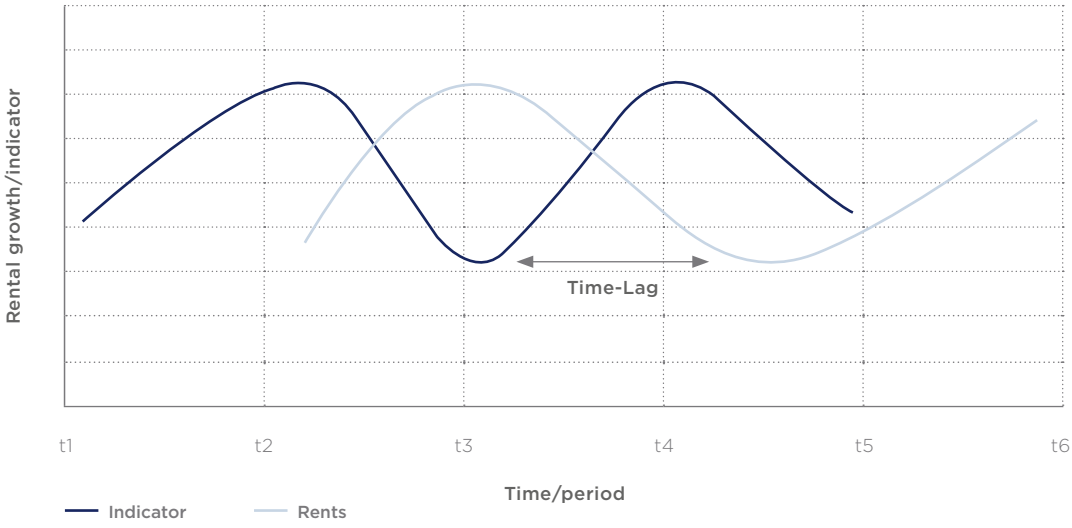


Figure 9: Time lag
Source: own graphic

06 | Research results at German national level

The correlation analysis at national level makes use of the German rent index published by the Federal Statistical Office. This index comprises rents (exclusive of service charges and ancillary costs) for existing and new-build properties. Time series data relating to potential parameters are compared to residential rents.

It appears obvious that the rental growth would correlate with the change in the overall price level. This arises not just from the macroeconomic correlations but also from a statistical perspective, as rents are also included in the overall consumer price index (CPI). The relationship between CPI and rents was thus investigated first. It is surprising that the correlation with the rent index is actually relatively slight. This cannot be explained by deviations in the data base or calculation methods, as both sets of indices are calculated and published by the Federal Statistical Office. Figure 10 shows the course of both indices (lines based on the left hand scale – base year = 2010) and their year-on-year growth rates (columns based on the right hand scale).

Figure 10: Rent index and CPI index growth
Sources: Federal Statistical Office; own calculations

There are various phases over the entire review period. Prior to the onset of the financial crisis in 2007, the CPI index had trailed the rent index for around 10 years. Until the end of the 1990s, some annual rental growth rates had been well above the increase in overall price levels. Then, there was very weak dynamic in the German economy during the early to mid-2000s. Rental growth during this period was below the overall price development. The CPI was driven by falling interest rates and rising prices for raw materials. Over the last few years (visible in the graphic from the year 2014), the rent index overtook the

growth in CPI a number of times (with the exception of 2017) in line with a period of robust economic growth and a significant rise in employment numbers.

It is noticeable from the overall analysis that the rental growth shows significantly less variance than overall price growth. The reason for this is the inclusion of rents for existing lease contracts (not just new lettings) with their existing lease terms and irregular rental adjustments. This results in a certain level of smoothing, as the rental growth for new lettings only forms part of the rent index.

In addition to CPI, many other relationships were tested. Of the total of 60 relationships investigated (12 parameters, each with 5 points in time), there were 18 statistically significant correlations; half of which showed a significance of at least a relatively high level of 5% (p-value <= 0.05).

Figure 11 shows an overview of the results of the analysis at national level.

CORRELATION UNDER REVIEW	TIME LAG/DELAY	CORRELATION COEFFICIENT	P-VALUE
Rent index vs population	Synchronous	**0.574**	**0.0092*****
	1 year	0.398	**0.0829***
	2 years	0.406	**0.0759***
	3 years	0.084	0.7313
	4 years	–0.086	0.7348
Rent index vs nominal GDP	Synchronous	0.104	0.6626
	1 year	0.314	0.1769
	2 years	0.066	0.7808
	3 years	0.223	0.3576
	4 years	0.276	0.2674
Rent index vs GDP/capita	Synchronous	0.005	0.9873
	1 year	0.183	0.4371
	2 years	0.171	0.4682
	3 years	0.270	0.2622
	4 years	0.189	0.4514
Rent index vs disposable income of private households/capita	Synchronous	–0.278	0.2341
	1 year	0.071	0.7673
	2 years	0.035	0.8826
	3 years	0.002	0.9931
	4 years	–0.170	0.4994
Rent index vs gross salary/employee	Synchronous	**0.751**	**0.0013*****
	1 year	0.392	0.1489
	2 years	0.395	0.1448
	3 years	0.485	**0.0788***
	4 years	0.213	0.4841

CORRELATION UNDER REVIEW	TIME LAG/DELAY	CORRELATION COEFFICIENT	P-VALUE
Rent index vs No. of persons in employment	Synchronous	–0.012	0.9620
	1 year	0.056	0.8164
	2 years	**0.500**	**0.0246****
	3 years	0.419	**0.0745***
	4 years	–0.004	0.9871
Rent index vs unemployment rate	Synchronous	0.056	0.8164
	1 year	–0.060	0.8016
	2 years	–0.331	0.1539
	3 years	–0.300	0.2125
	4 years	–0.100	0.6944
Rent index vs new building permits for apartments in multi-family apartment buildings	Synchronous	0.229	0.3309
	1 year	0.129	0.5856
	2 years	0.388	**0.0910***
	3 years	0.438	**0.0608***
	4 years	0.471	**0.0416****
Rent index vs completions of apartments in multi-family apartment buildings	Synchronous	0.244	0.2993
	1 year	0.208	0.3783
	2 years	0.304	0.1925
	3 years	**0.588**	**0.0063*****
	4 years	0.426	**0.0610***
Rent index vs vacancy rate	Synchronous	**–0.502**	**0.0673***
	1 year	**–0.577**	**0.0309****
	2 years	–0.272	0.3475
	3 years	**–0.712**	**0.0064*****
	4 years	–0.493	0.1031
Rent index vs house price index	Synchronous	0.489	**0.0641***
	1 year	0.386	0.1584
	2 years	**0.796**	**0.0004*****
	3 years	**0.646**	**0.0125****
	4 years	0.292	0.3326
Rent index vs CPI index	Synchronous	0.140	0.5551
	1 year	–0.017	0.9468
	2 years	–0.278	0.2358
	3 years	0.035	0.8841
	4 years	–0.087	0.7148

****1% significance; **5% significance; *10% significance*

Figure 11: Overview of German correlation analysis
(bold: correlation coefficients >=0.5 and <=-0.5; all p-values indicating significance)
Sources: Thomas Daily, Federal Statistical Office, State Statistical Offices, Federal Employment Agency, Statista; own calculations

The highest correlation coefficient (0.796) is shown by the house price index with a delay of two years until the effects impact rental growth, which indicates a strong relationship between the two parameters. Rents appear to adjust in the direction of house prices after a time delay. Rising house prices are followed two years later by a rise in rents, and a fall in prices is followed by stagnating (but still positive) rental growth.

The rent index also clearly correlates with gross salaries (2nd place for the synchronous data series) and vacancy rate (3rd place with a time lag of three years).

Figure 12 shows the respective movements. Of note is the fact that the negatively correlating change in the vacancy rate is shown as a mirror image (inverse correlation).

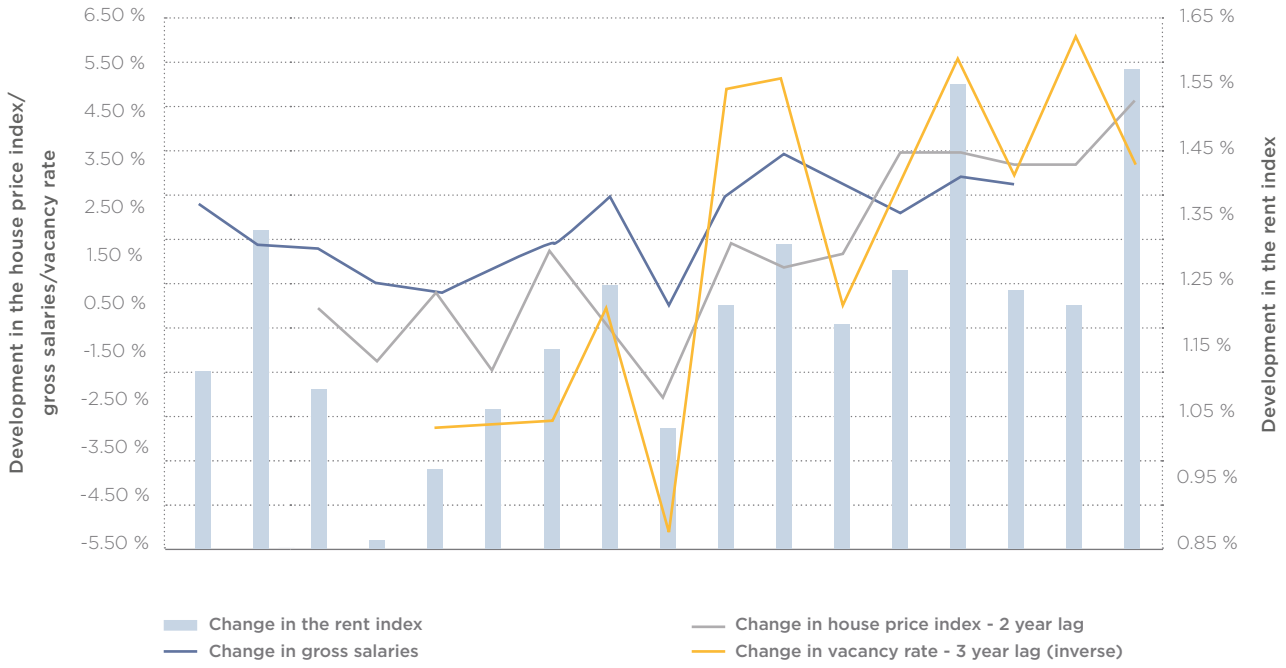


Figure 12: Development in the house price index (lag: 2 years), gross salaries (synchronous) and vacancy rate (lag: 3 years, inverse) to the rent index
Sources: Thomas Daily, Federal Statistical Office, State Statistical Offices, Statista; own calculations

Even if the results for GDP (nominal and per capita) and disposable income do not indicate any effect in this particular investigation, this conclusion does not necessarily apply to other socio-economic factors. A change in the number of persons in employment shows significance with a lead of two to three years, which indicates a positive correlation with rent levels.

As shown above, the correlation coefficient of gross salaries shows the 2nd highest value of all relationships tested when viewed synchronous with the rent index. Actual increases in the level of salaries appear to have an effect on prices in the rental apartment segment, but not necessarily positive economic conditions alone, which tend to be reflected in GDP.

The growth of population also appears relevant with three significant values. This result is theoretically plausible in view of the resulting positive correlation.

The interpretation of the positive correlation between new building permits and completions (both with a lead of two to four years ahead of rental growth) is relatively vague. In terms of economies of scale, an increase in supply should serve to limit rental growth, as an excess of demand is reduced and competition between suppliers is rising. The resulting correlation is not negative though. Conversely there could be an urgent requirement to replace existing stock i.e. the new-build activity is replacing only obsolete stock. However, this will not necessarily result in a positive correlation. There is likely to be a qualitative effect, which has an impact on the market variable used for this analysis. Newly constructed residential space is typically let at significantly higher rental levels than existing stock for the same size and location. In dynamic markets with a high proportion of new-build activity, the rent index is likely to react accordingly, in anticipation of this factor. The correlation detected here is relatively uncertain and, therefore, ineligible for explaining and forecasting residential rents. In this sense, new building permits and completions are rather criteria for the overall market dynamic, as their effect must be analysed in different ways.

07 | Research results at city level

In a further phase we conducted a correlation analysis at city level. The data set comprises 80 larger cities with populations in excess of 70,000. This subset of the first analysis includes around 30% of the German population and is intended to exclude locations, which comprise a very small rental apartment segment and, hence, are not the focus for institutional investors anyway. The selection is also based on the achievable level of transparency, in particular concerning the availability of statistical data on rents and other parameters. Small towns and communities dominate the national analysis based on the total population; however their respective residential markets are not necessarily comparable with the larger cities. More rural regions are characterised by higher ownership rates and in some cases larger numbers of private lettings, which affect the development in the parameters under review and could produce different results compared to the rental apartment markets in the larger cities. The selection of cities is intended to focus on trends in the residential markets, which are of particular interest to investors.

The initial correlation analysis for complete time series data at national level will not be repeated for each and every city. Instead of interdependencies relating to annual data points, this part of the study will be based on an overall medium-term investment horizon. For this analysis the respective rates of change for each city are calculated over a ten year period based on time series. The statistical sample utilises a greater number of data points (now 80 per parameter), which provide an improved basis for the correlation analysis. The rental growth under review is specifically concentrated on the new-build segment (€/m², 60 m² - 80 m², constructed since 2000, high specification fit-out), which provides a better picture of how the rental market reacts. These adjustments in methodology and data series mean that the results of the analyses at national and city levels are not directly comparable. However it is interesting whether both sets of data at least show similar parameters with significant correlations.

The results of the correlation analysis at city level are shown in Figure 13.

CORRELATION UNDER REVIEW	TIME LAG/DELAY	CORRELATION COEFFICIENT	P-VALUE
Rents vs population	Synchronous	**0.357**	**0.0012*****
	1 year	**0.316**	**0.0043*****
	2 years	**0.306**	**0.0057*****
Rents vs nominal GDP	Synchronous	**0.350**	**0.0015*****
	1 year	0.201	**0.0739***
	2 years	0.203	**0.0716***
Rents vs GDP/capita	Synchronous	0.170	0.1322
	1 year	0.078	0.4908
	2 years	0.082	0.4678
Rents vs disposable income of private households/capita	Synchronous	–0.051	0.6560
	1 year	0.228	**0.0418****
	2 years	0.269	**0.0158****
Rents vs gross salary/employee	Synchronous	0.210	**0.0614***
	1 year	0.040	0.7257
	2 years	0.114	0.3144

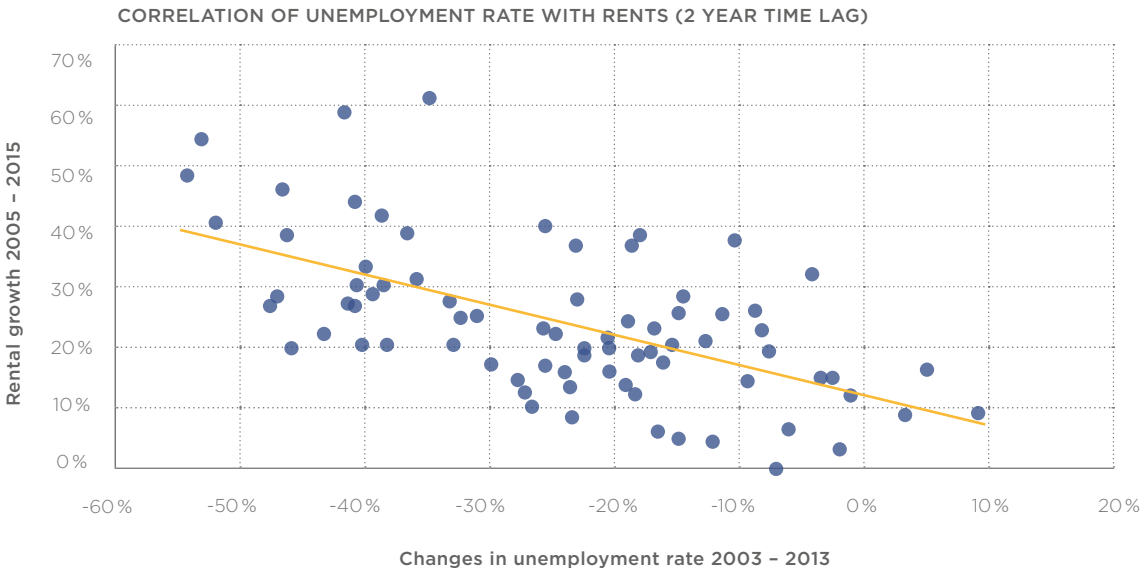
CORRELATION UNDER REVIEW	TIME LAG/DELAY	CORRELATION COEFFICIENT	P-VALUE
Rents vs No. of persons in employment	Synchronous	**0.351**	**0.0014*****
	1 year	**0.365**	**0.0009*****
	2 years	**0.335**	**0.0024*****
Rents vs unemployment rate	Synchronous	**–0.548**	**0.0000*****
	1 year	**–0.539**	**0.0000*****
	2 years	**–0.554**	**0.0000*****
Rents vs new building permits for apartments in multi-family apartment buildings	Synchronous	**0.292**	**0.0085*****
	1 year	0.272	**0.0146****
	2 years	0.218	**0.0525***
Rents vs completions of apartments in multi-family apartment buildings	Synchronous	0.184	0.1016
	1 year	0.156	0.1658
	2 years	0.137	0.2254
Rents vs completions of space in multi-family apartment buildings	Synchronous	0.137	0.2261
	1 year	0.103	0.3618
	2 years	0.110	0.3310
Rents vs purchase prices for condominium apartments	Synchronous	**0.396**	**0.0003*****
	1 year	**0.412**	**0.0001*****
	2 years	**0.439**	**0.0000*****

******1% significance; **5% significance; *10% significance***

Figure 13: Overview of correlation analysis at German city level
(n = 80, populations in excess of 70,000, bold: all correlation coefficients with 1% significance; all p-values indicating significance)
Sources: Thomas Daily, Federal Statistical Office, State Statistical Offices, Federal Employment Agency; own calculations

Certain parameters relating to the labour market emerge on the demand side. The change in employment numbers and unemployment rates show the highest correlation coefficients and high levels of significance over all time periods under review. Any change in employment levels should have a corresponding effect on demand. Rising purchasing power and more optimistic estimates, though, should typically affect rents in the new-build segment. Other demand-related factors such as disposable incomes confirm this (in this case with a lead time of one and two years). In addition to these parameters, the overall demand is also affected by population growth. Correlations between population and rental growth already became clear in the national analysis.

Figure 14 shows a visual comparison of the strongest correlation (upper chart: unemployment rate, time lag 2 years) and the weakest correlation (lower chart: gross salaries, time lag 1 year).



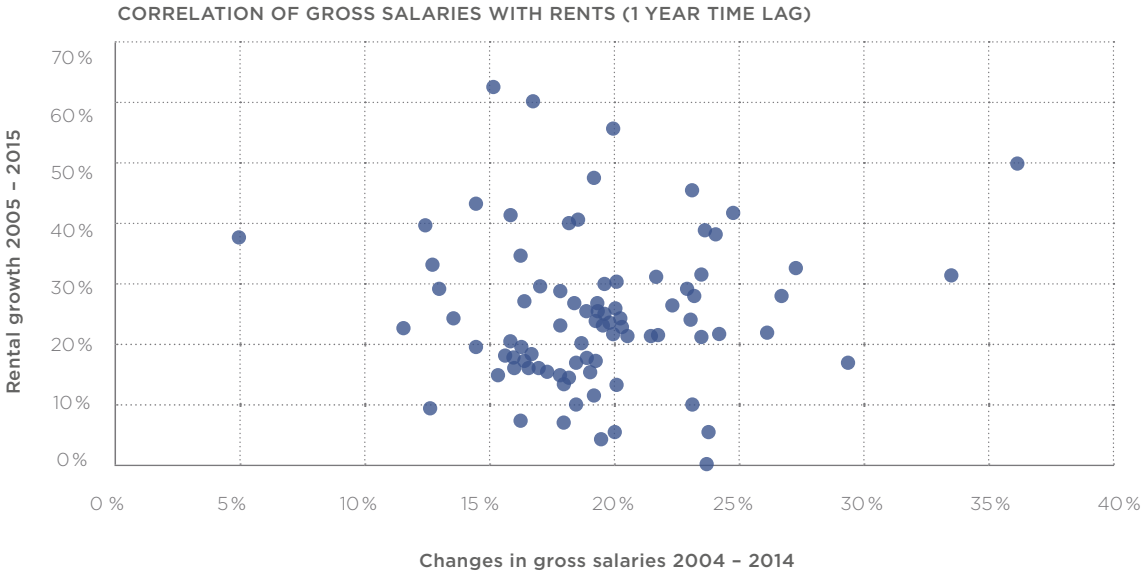


Figure 14: Scatter diagrams, indicators with the highest (upper chart) and lowest (lower chart) correlation coefficients for 80 German cities with population in excess of 70,000
Sources: Thomas Daily, Federal Statistical Office, State Statistical Offices, Federal Employment Agency; own calculations

The analysis of this sample also highlights the effect of regional economic development (nominal GDP) on rents. Figure 15 shows examples of four cities with very strong and four cities with very weak GDP growth and shows the rental growth as the comparable indicator. It becomes apparent that the locations with the highest GDP growth rates also show similarly high growth in rents, in all cases above the median (the yellow line) rental growth for the entire sample over the period under review. By contrast the sample cities with low dynamic in terms of GDP growth mostly show rental growth below the level for the entire sample under review.

COMPARISON OF GDP GROWTH AND RENTAL GROWTH 2005 – 2015

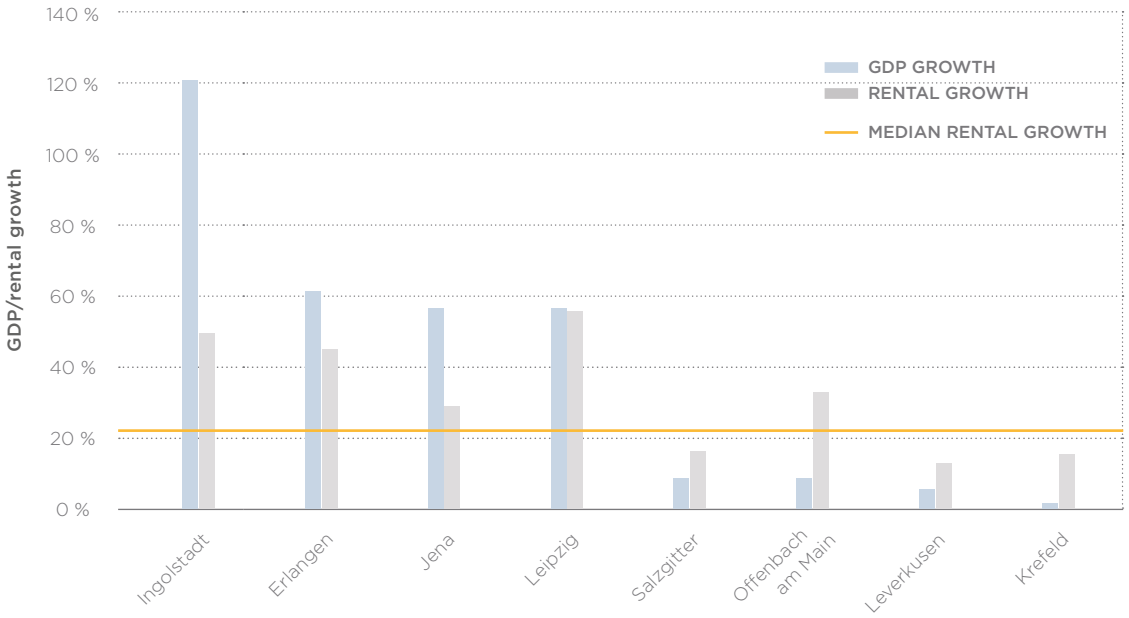


Figure 15: Comparison of GDP growth and rental growth 2005 - 2015, top 4 and bottom 4
Sources: Thomas Daily, State Statistical Offices; own calculations

Demand-related factors appear to be generally applicable for the cities with populations in excess of 70,000 under review. According to the results, the rents in the new-build segment react noticeably to quantitative demand changes as a result of population growth and also to changes in qualitative demand factors, for example as a result of improvement/deterioration in employment prospects (labour market indicators) in combination with the resulting consumer factors (change in disposable incomes).

One further significant factor/correlation is evident from the purchase prices for condominium apartments. Changes in purchase prices do not simply follow rental growth (which would be the result in the case of the capitalised income value), but rather changes in purchase prices tend to precede rental growth in many cases. In terms of larger cities, purchase prices (in this case for condominium apartments) play an important role in explaining rental growth (high levels of significance, positive correlation with rents). If prices for condominium apartments increase, a rise in residential rents often follows after a time delay.

Completions (apartments and residential space) show low correlation coefficients and are statistically insignificant. By contrast the numbers of building permits are statistically significant to some extent. In conclusion, these construction-related supply side parameters can hardly be used to explain and forecast the market. This is true at least for the medium-term timeframe under review of around 10 years. In this period rents in the new-build segment in larger cities tend to be driven mainly by demand side parameters.

08 | Results of the analyses at city and federal level

Figure 16 shows a summary of the results of the correlation analysis. This table shows only the resulting indicators and time factors, which proved to be significant (at least 10% level).

INDICATOR UNDER REVIEW	CITIES		GERMANY	
	Time lag/delay	Correlation coefficient	Time lag/delay	Correlation coefficient
Population	Synchronous	0.357***	Synchronous	0.574***
	1 year	0.316***	1 year	0.398*
	2 years	0.306***	2 years	0.406*
Nominal GDP	Synchronous	0.350***	–	–
	1 year	0.201*	–	–
	2 years	0.203*	–	–
Disposable income of private households/capita	1 year	0.228**	–	–
	2 years	0.269**	–	–
Gross salaries/employee	Synchronous	0.210*	Synchronous	0.751***
	-	-	3 years	0.485*
No. of persons in employment	Synchronous	0.351***	2 years	0.500**
	1 year	0.365***	3 years	0.419*
	2 years	0.335***	–	–
Unemployment rate	Synchronous	-0.548***	–	–
	1 year	-0.539***	–	–
	2 years	-0.554***	–	–
New building permits for apartments in multi-family apartment buildings	Synchronous	0.292***	2 years	0.388*
	1 year	0.272**	3 years	0.438*
	2 years	0.218*	4 years	0.471**
Completions of apartments in multi-family apartment buildings	-	-	3 years	0.588***
	-	-	4 years	0.426*
Purchase prices for condominium apartments	Synchronous	0.396***		
	1 year	0.412***		
	2 years	0.439***		
Vacancy rate			Synchronous	–0.502*
			1 year	–0.577**
			3 years	–0.712***
House price index			Synchronous	0.489*
			2 years	0.796***
			3 years	0.646**

***1% significance; **5% significance; *10% significance*

Figure 16: Overview of correlation analysis at city and national level (n = 80, populations in excess of 70,000), significant parameters
Sources: Thomas Daily, Federal Statistical Office, State Statistical Offices, Federal Employment Agency, Statista; own calculations

As the results are dependent on the individual samples under review, they must be seen simply as an indication for possible correlations in the market. In order to exclude for example spurious correlations further tests (e.g. for longer time series, varying time periods, city clusters) as well as the qualitative examination of causalities (e.g. input-output models, case studies) are required. However, the findings of this study give a first overview of relevant parameters, which may be use to explain and forecast the rental apartment markets.

09 | Conclusion: practical application and requirement for further research

The overall analysis is dominated above all by indicators, which characterise the supply side of the residential property market and are predominantly based on existing stock (e.g. property prices) and less development-related (e.g. numbers of completions).

Purchase price growth (houses, condominium apartments) are relevant parameters. From a historical viewpoint, cities like Erlangen, Ingolstadt, Bayreuth and Berlin are amongst the Top 10 in Germany in terms of both growth in purchase prices and rents. By contrast Hagen, Wuppertal and Oberhausen are well behind in terms of these parameters. There is some crossover in the case of valuations in terms of the capitalised income value, but arbitrary factors – above all whether to buy or rent - also play an important role. Similarly remarkable is the effect of vacant but marketable apartments, which can only be analysed at national level because of a lack of detailed time series data at city level.

In the cities under review, demand side indicators appear to be relevant for rental growth. In addition to population and GDP growth, it seems worthwhile to conduct a more detailed investigation into (anticipated) trends on the labour market, if one wishes to estimate future changes in rents. Changes in employment numbers and the unemployment rate show high correlation coefficients at all points of the period under review, which are also accompanied by high levels of significance. In terms of the individual rankings of the parameters GDP and rents, six cities (Ingolstadt, Erlangen, Leipzig, Berlin, Bayreuth and Erfurt) are present in both Top 10 lists. Following on from this, the parameter disposable income is also an important leading indicator.

Both the number of new building permits and completions tends to result in an increase in the stock of apartments but are different in terms of their statistical explanatory power. New building permits (positive correlation)

are relevant for both sides. There are relatively high numbers in Ingolstadt, Erlangen and Bayreuth and these cities are also in the Top 10 in terms of rents. The number of completions, by contrast, appears to be a relevant statistical factor only at national level. Possible causes for this divergence may be methodical differences in the data series and relationships under review or the specific selection of cities as a subset for the national sample. There will be no more detailed analysis on this topic in this report. The rankings of parameters and variables can be compared from Figure 17.

INDICATOR	PARAMETERS					VARIABLE
Rank	Population growth	GDP growth	Change in employment numbers	New building permits/1,000 inhabitants	Purchase price growth for condominium apartments	Rental growth
1	Munich	**Ingolstadt**	**Ingolstadt**	Regensburg	Freiburg	**Berlin**
2	**Leipzig**	**Erlangen**	Wolfsburg	**Ingolstadt**	Munich	**Bayreuth**
3	Potsdam	Jena	**Erlangen**	Potsdam	Brandenburg	**Leipzig**
4	Frankfurt	**Leipzig**	Jena	Oldenburg	Mainz	**Ingolstadt**
5	Münster	Regensburg	Freiburg	**Erlangen**	**Erlangen**	**Dresden**
6	**Dresden**	**Berlin**	**Berlin**	Munich	**Ingolstadt**	**Erlangen**
7	Regensburg	Potsdam	**Leipzig**	Münster	Frankfurt	**Würzburg**
8	Darmstadt	Cologne	Bremerhaven	Frankfurt	**Bayreuth**	**Erfurt**
9	Trier	**Bayreuth**	Münster	Fürth	Bremerhaven	**Heilbronn**
10	Freiburg	**Erfurt**	Hamburg	**Bayreuth**	**Berlin**	**Augsburg**
...						
71	Bochum	**Hagen**	Chemnitz	Krefeld	Solingen	**Leverkusen**
72	**Gelsenkirchen**	**Remscheid**	**Hagen**	**Hagen**	Chemnitz	**Bottrop**
73	Brandenburg	Wilhelmshaven	Krefeld	Halle	**Hagen**	**Wuppertal**
74	Cottbus	**Duisburg**	Schwerin	Gera	**Wuppertal**	**Oberhausen**
75	**Hagen**	Mülheim	Wilhelmshaven	**Gelsenkirchen**	**Oberhausen**	**Kiel**
76	Salzgitter	Bremerhaven	**Remscheid**	**Duisburg**	Heidelberg	**Kaiserslautern**
77	Herne	Salzgitter	Halle	Bochum	Gera	**Gelsenkirchen**
78	Wilhelmshaven	Offenbach	Herne	**Wuppertal**	Delmenhorst	**Hagen**
79	**Remscheid**	**Leverkusen**	Gera	Salzgitter	Wilhelmshaven	**Remscheid**
80	Gera	Krefeld	Cottbus	Herne	Neumünster	**Duisburg**

Figure 17: Ranking TOP/BOTTOM of 80 cities – 10-year change in relevant parameters (2005 - 2015)
Sources: Thomas Daily, Federal Statistical Office, State Statistical Offices, Statista; own calculations

The determined rankings show the trends in the cities under review to date, but they do not necessarily provide any recommendation in favour of new investments. Moreover the comparisons show the overall market relationships. If one wishes to forecast future changes in rents, it is necessary to determine the relevant economic and property market-related indicators. Check lists and overviews including the relevant parameters (according to this study these include the medium-term analysis of the labour market, population, GDP, new building permits and purchase prices) should form part of all investment decision-making documentation.

OVERVIEW – HIGHEST CORRELATION COEFFICIENTS BY PERIOD

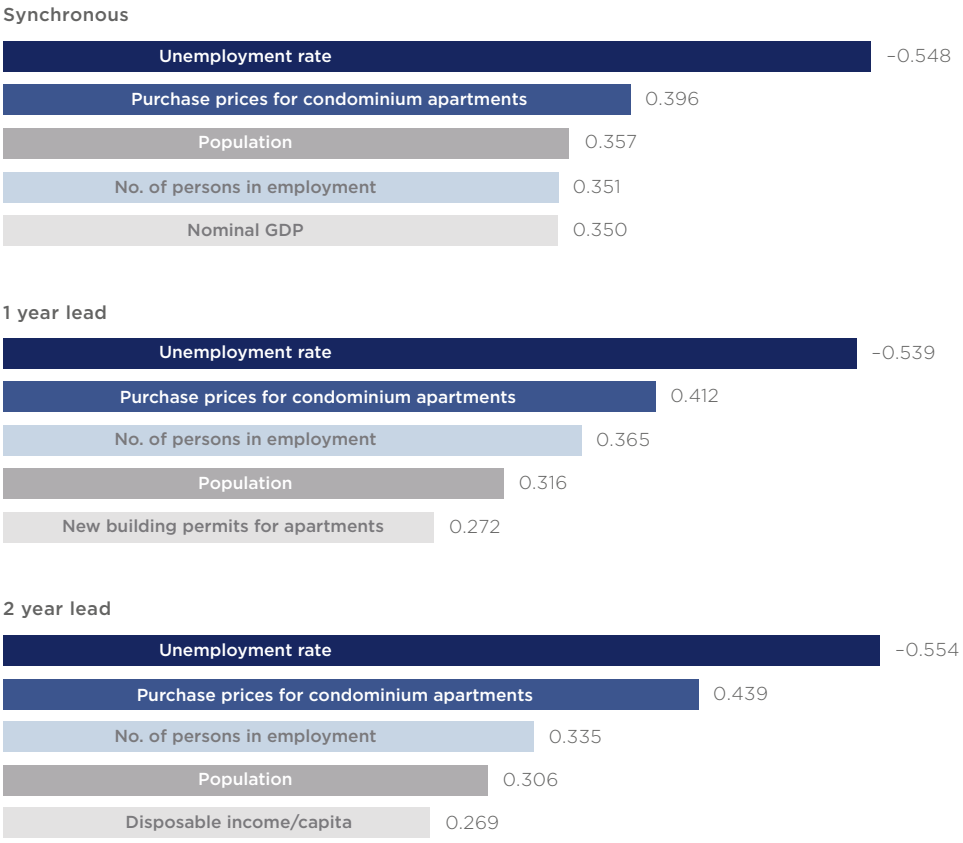


Figure 18: Overview of the five highest correlation coefficients at city level, differentiated by analysis period
Sources: Federal Statistical Office, State Statistical Offices, Federal Employment Agency, Thomas Daily; own calculations

A forecast in its narrowest sense has not yet been achieved. But the analysis of the parameters can provide a relevant pre-selection of cities for investment decision-making and portfolio management purposes. It should also be possible to make a tentative estimate of future rental growth. However the focus of prospective investors on particular (sub) markets in the residential segment requires closer investigation to be able to provide any statements on the development of individual locations in this context.

Building on the basis of this study, the Empira group's further research will focus increasingly on the further disaggregation of the sample of 80 cities with populations in excess of 70,000 under review. On the basis of a further clustering by evident factors and their closer analysis, it should be possible to derive even more differentiated results. In particular a look at the dynamic development (year-on-year growth) of the parameters already tested here at individual city level may show which markets are particularly robust or volatile. This alternative investigation concept will offer the possibility to analyse an entire cycle and amongst other things to provide an insight into the occurrence and impact of crises/peaks at a regional level. One key objective is the identification of safe havens for investors and also the early recognition of risky and unprofitable markets.

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