The rationale behind a multi-indicator approach to real estate price analysis

Thomas A. Knetsch, Christine Schlitzer and Elena Triebskorn[1]

Deutsche Bundesbank, Directorate General Statistics

PRELIMINARY AND INCOMPLETE VERSION

25 January 2019

Abstract

Policymakers urge timely, reliable and comprehensive information about real estate prices for economic and financial stability analyses. However, official statistics are only partly able to meet the demand, with data gaps being much larger for commercial real estate than for residential. In some fields, the statistics community has not yet achieved a consensus on appropriate data sources, measurement concepts and practices. In part, this is linked to ongoing discussions with users about what the various policy uses imply for index compilation and breakdowns. Until these issues remain unsolved, but maybe also beyond, it is advisable to follow a multi-indicator approach to real estate price analysis, i.e. make use of all sources which deem to fulfil the quality standards of sound statistics to a sufficiently high degree. An empirical evaluation of this approach using real estate price indices available for Germany provides the following main results. First, the uncertainty entailed in the usage of a variety of indicators might be regarded as limited if price indices do not suffer from a coverage mismatch. This condition is met first and foremost for residential rather than in commercial property and for indices covering only metropolitan areas rather than the country as a whole. Second, measurement deviations in residential property prices are shown to be due more to differences in source data than in weighting schemes. Third, transaction-based real estate price indices provide a more distinctive volatility and correlation pattern than their appraisal-based counterparts. Fourth, the deviations between the residential property price indices of following different definitions in use […].

JEL Codes: C 43, E 31, R 31, R 33

Keywords: Real estate prices, index numbers, economic analysis, financial stability analysis

[1] The authors thank Alexandra Päckert and Patrick Schwind for excellent research assistance. It is gratefully acknowledged that vdpResearch GmbH provided residential property price indices of the 401 German administrative districts and in the breakdown by the settlement structures. The views expressed in this paper are solely ours and should not be interpreted as reflecting the views of the Deutsche Bundesbank.

1 Introduction

Real estate price measurement does not belong to the fields in statistics which have been settled in institutional and methodological terms. National accounts, balance of payment statistics, consumer price statistics and other established statistical reporting systems are based on either globally binding measurement principles or, at least, a broad consensus about sound measurement practices. Furthermore, countries have generally entrusted national institutions with compilation and, as long as the public ascribes a high quality to their results, no alternative provider is able to contest for the information provision monopoly.

Such a mature stadium is far from being reached in real estate price statistics. Looking around the globe, the availability of official data on real estate prices is still limited overall, albeit a distinction has to be made between residential and commercial property. Official statistics have made significant progress in the provision of residential property price indices (RPPI) for the last two decades. The international community agreed upon a Handbook on RPPIs which details sound principles regarding measuring practices (Eurostat, 2013), and national statistical institutes of many countries started publishing indices following these rules and recommendations. By contrast, the discussion among statisticians, users and scholars how to generate source data for commercial property price indices (CPPI) and conceptualise compilation is still in its infancy,[2] implying that the public must wait a rather long time until official CPPIs will be published.

The insufficient provision of statistics contrasts the high, and steadily rising, demand for ready, comprehensive and reliable data on real estate prices. Especially since the global financial crisis, policymakers urge detailed information about real estate markets for financial stability purposes. While, in the case of lacking official data, analysts rely on available private sources, the statistics community has intensified efforts to reduce data gaps. For real estate prices, this means that, on the one hand, official statistical institutions are required to set up strategies targeting a regular publication at least in the long run. On the other hand, economic and prudential analysts should meanwhile be provided with price indices fulfilling statistical quality standards to a sufficiently high degree.[3]

The current interim stadium gives rise to follow a multi-indicator approach to real estate price analysis. The idea is that, in the absence of a price index (or better: a group of price indices from a coherent source) outperforming all alternatives in any and every possible way, it is

[2] Eurostat (2017) is a text agreed upon by international statistical institutions which is aimed at informing about source data, conceptual framework and methodologies to compile CPPIs. As it is too early to formulate (binding) recommendations, the text is explicitly not titled handbook.

[3] In their intermediate position between producers and users of statistics, central banks have often taken a part in qualifying existing sources as being useful for analytical purposes. In Germany, for instance, the Deutsche Bundesbank has helped shape the process of providing a sound information base on German real estate market for a long time. In addition, it has offered price information, with important landmarks being the regular publication of RPPIs on the basis of data provided by bulwiengesa AG starting in spring 2003 (Deutsche Bundesbank, 2003; Leifer, 2004) and the releases of systems of indicators for the German residential and commercial property markets being online since autumn 2015 and autumn 2017 respectively.

worth assembling those price indices (or groups) which stand out due at least to one comparative advantage while meeting minimum standards in all other quality dimensions. A multi-indicator approach is beneficial not only when data sources, methods, classifications and the like are still under discussion but also when a single index (or group), even if it is deemed to perform best in statistical terms, is unable to serve all analytical purposes. However, the coexistence of indicators measuring either the same phenomenon or closely related ones comes at the cost of inducing measurement uncertainty and may entail the risk of confusing the public.

The diversity of real estate price indices has so far been documented and analysed predominantly for the residential segment. Silver (2011) surveyed the sets of RPPIs available for the US, UK and Russia and sketched options to improve the "unsatisfactory situation of competing measures with different outcomes". Concerning Silver's option "Develop standards", the international statistical community has made significant progress, and his option "Identify an official series" was put into practice in the UK in June 2016 following the National Statistician's (2010) recommendation to construct a "definite official house price measure". By evaluating a panel of over 150 house price series covering 24 countries, Silver (2014) figured out that measurement matters for real estate analysis and policy formulation, in particular during recessions. This study contributes to the literature evidence on Germany and for both residential and commercial real estate price indices.

The suite of price indices considered in the multi-indicator approach is shaped by a data source and a policy use dimension. The former exists because of the variety of real estate price indices available from different data providers. The latter results primarily from the fact that the classification of property types, in particular the delineation between residential and commercial real estate, depends on the policy use of price indices. While there is a broad consensus about assigning (owner-occupied) houses and apartments to residential property and office and retail to commercial property, statisticians and analysts debate on the role of multi-family dwellings (and buy-to-let property), as these object types share usage with the former and owners' profit orientation with the latter group. As regards data availability and index compilation, however, what is said about CPPI applies in the same way to multi-family dwellings price indices (MDPI). Hence, the first, more data-related, parts of the paper deal with MDPI either together with CPPI or separately as an in-between type. In the final part where aggregation across object types is studied against the backdrop of various analytical purposes, the assignment of multi-family dwellings (and buy-to-let property) comes into the focus of debate.

The pros and cons of the multi-indicator approach are exemplified considering the current data provision about German real estate markets. On the one hand, Germany turns out to be a typical case for many industrialised and emerging countries given that the existing infor-

mation gaps in official data are bridged by private sources as effectively as possible. On the other hand, there are quite a few private providers of price data of sufficiently high quality. This makes it possible to, first, quantify and decompose measurement uncertainty among indicators and, second, illustrate some important issues of index compilation such as coverage, breakdown, classification and weighting by empirical examples. The price data under consideration has been scrutinised by the Deutsche Bundesbank for many years (e.g. Hoffmann and Lorenz, 2006) and consists, to the overwhelming part, of the information it publicly releases within the systems of indicators for the German residential and commercial property markets.[4]

The paper is organised as follows. In Section 2, an overview on price indices for real estate in Germany is presented. In Section 3, some metrics of measurement uncertainty among indicators are calculated for RPPIs and CPPIs including breakdowns as well as MDPIs. Furthermore, a decomposition of measurement deviations into data source and weighting effects is provided for RPPIs. In Section 4, the volatility of the price changes of different types of real estate and the correlation among each other and with key macroeconomic variables and analysed. In Section 5, the various uses for real estate price statistics and their implications on how to delineate residential and commercial property are discussed. Using German data, price indices of residential property following the main definitions in use are calculated and compared. In Section 6, conclusions are drawn.

2 Overview on price indices for real estate in Germany

The availability of residential property prices in Germany has been significantly expanded over the past few years. The residential market is meanwhile covered adequately. In concrete terms, price developments for Germany as a whole can be studied using official data sources and, in particular, when the regional dimension is in the focus, too, the analysis can be complemented by a number of indices from private data providers. By contrast, due to the lack of official data on commercial real estate prices, analyses in this market segment are based solely on private data sources.

The various real estate price indices differ in terms of periodicity, timeliness and the availability of breakdowns. In general, disaggregation refers to geographical entities (e.g. regions, city groups) and object types. Furthermore, they are compiled using different data sources, index methodologies and weighting schemes. In Section 2.1, RPPIs and their characteristics are sketched. Section 2.2 is devoted to the description of CPPIs and MDPIs.

[4] The system of indicators for the German residential property market can be accessed via www.bundesbank.de/residential_property and the system of indicators for the German commercial property market via www.bundesbank.de/commercial_property. Both systems are partitioned in three blocks, namely price indicators, financial indicators and real economic indicators.

2.1 Price indices available for residential real estate in Germany

Four data providers publish price indices for Germany as a whole. The Federal Statistical Office (Destatis) produces an official RPPI which is called house price index (HPI) though it covers apartments as well. It is compiled on the basis of transactions using measurement concepts harmonised across the European Union. Among the price indices from private providers, three stand out as they fulfil quality requirements, which are usually attributed to price indices, at a sufficiently high degree. To this group belongs the RPPI published by the Deutsche Bundesbank. It is produced on the basis of the appraisal data collated by the bulwiengesa AG, a German real estate consulting firm, using appropriate weights such as the volumes of transactions or assets. Another private RPPI is provided by the vdpResearch GmbH, a real estate research-oriented subsidiary company of the Association of German Mortgage Banks (vdp). The price indices are compiled on the basis of transaction data enclosed to credit applications. A similar approach is used for the data underlying the price indices published by Hypoport AG.

Table 1 Overview on main German RPPIs

	Destatis (HPI)	bulwiengesa	vdp	Hypoport
Coverage	Germany	Germany	Germany	Germany
Quality adjustment	Hedonic	Stratification	Hedonic	Hedonic
Breakdown by object types	New buildings / resale	Houses / apartments, new buildings / resale	Houses / apartments	Houses / apartments
Regional breakdown	None	7 largest cities / 127 towns and cities, large district-free towns and cities / urban districts / more densely populated rural areas / sparsely populated rural areas	7 largest cities, large district-free towns and cities[1] / urban districts[1] / more densely populated rural areas[1] / sparsely populated rural areas[1]	None
Aggregation	Not applicable	Weighted average	Not applicable	Not applicable
Frequency	Quarterly	Annual	Annual / quarterly	Quarterly
Time series start	2000	1995 / 2004	2003 / 2008	2005
Timeliness	t+85 days	t+45 days	t+40 days	t+40 days
Origin of data	Transactions	Various sources[2]	Transactions	Transactions

1) vdp provided regional data based on the classification suggested by BBSR for Deutsche Bundesbank. These data are not published on a regular basis.

2) bulwiengesa uses various sources such as media coverage, market reports, valuers, internet platforms and others.

In Table 1, the main attributes of the RPPIs under consideration are summarised. For the subsequent analysis, it is worth detailing on the breakdowns by object types and in regional dimension. RPPIs amalgamating information about houses and apartments and covering Germany as a whole (RPPI-DE) are released by four providers while the breakdown by object types is currently available only from bulwiengesa, vdp and Hypoport. Analysts of the German real estate market pay a particular attention to price developments in the seven

largest cities.[5] RPPI-C7s (including the breakdown in houses and apartments) are offered by the three private providers. The regional breakdown along settlement structures (RPPI-SS) is expected to gain importance as Destatis plans to disaggregate the HPI accordingly. This breakdown draws on a classification suggested by the Federal Institute for Reseach on Building, Urban Affairs and Spatial Development (BBSR). This classification groups the 401 administrative districts into 66 large district-free towns and cities, 137 urban districts, 102 more densely populated rural areas, and 96 sparsely populated rural areas.[6] RPPI-SSs are published by neither bulwiengesa nor vdp. However, with the district-level price indices to which the providers grant the authors access, they can be constructed.

2.2 Price indices available for commercial real estate and multi-family dwellings in Germany

In this paper, three providers of commercial real estate prices are taken into account. In strict terms, it is only the vdp that publishes CPPI for Germany as a whole (CPPI-DE). The bulwiengesa indices are also treated as CPPI-DE. However, they are only based on data for 127 towns and cities. In addition, the bulwiengesa indices focus on the prime segment, while vdp covers both prime and non-prime objects. Price indices of commercial real estate in the seven largest German cities (CPPI-C7) are provided by bulwiengesa. Jones Lang LaSalle (JLL), an investment management firm, also publishes a metropolitan CPPI which is based on data on the C7 group but Cologne. Similar to bulwiengesa, JLL uses prime-market information from various sources.

CPPI means here that the prices of office buildings and retail space are amalgamated. The three providers, however, also offer price indices for these two object types separately. The weighting of object types in CPPI differs significantly. In the vdp CPPI, office and retail buildings are aggregated according to the shares in outstanding loans granted by mortgage banks, implying that office is given about 60 per cent and retail about 40 per cent. By contrast, in the bulwiengesa CPPI office makes up a quarter and retail three quarters, representing the shares of the object types in tradable assets.

MDPIs are published by vdp and bulwiengesa, with the former covering Germany as a whole and the latter only 127 towns and cities. By focusing on the seven largest German cities (MDPI-C7), it is possible to compare MDPIs which are spatially homogenous. As with CPPIs, the prime/non-prime issue might be a source of mismatch nonetheless.

[5] The seven largest German cities are Berlin, Hamburg, Munich, Cologne, Frankfurt/Main, Stuttgart and Dusseldorf.

[6] For more information about the categorisation of districts in settlement structures, see the BBSR homepage, in particular: www.bbsr.bund.de/BBSR/DE/Raumbeobachtung/Raumabgrenzungen/Kreistypen4/kreistypen.html

Table 2 Overview on main German CPPIs and MDPIs

	bulwiengesa	vdp	Jones Lang LaSalle (JLL)
Coverage	127 towns and cities in Germany	Germany	6 major cities in Germany
Quality adjustment	Stratification	Hedonic	Stratification
Object types	Office, retail, industry, residential	Office, retail,	Office, retail, industry
Regional breakdown	7 largest cities	None	None
Aggregation	Weighted average over regions	Not applicable	Weighted average over cities
Frequency	Annual	Annual / quarterly	Quarterly
Time series start	1995	2003 / 2008	1981
Timeliness	t+45 days	t+40 days	t+15 days
Origin of data	Various sources[1)]	Transactions	Informed expert judgement based on transactions

1) bulwiengesa uses various sources such as media coverage, market reports, valuers, internet platforms and others.

Market participants usually valuate commercial real estate (including multi-family dwellings) using information about rents and net initial yields. These two pieces of information is principally sufficient for price index compilation as prices, rents and yields are mathematically linked.[7] Along this line of argument and because of the use of hedonic quality adjustment, the capital value indices published by vdp can be treated as price indices. bulwiengesa and JLL offer data on capital values from stratified samples. Therefore, these indicators can also be taken as constant-quality price indices. Table 2 summarises a number of attributes of CPPIs under consideration.

3 Measurement uncertainty of German real estate prices

Despite the aim of measuring the same entity, price indices may deviate from each other due to a number of reasons. These include, but are not limited to, data source, index concept, quality adjustment, and weighting. As described in the previous section, the price indices considered in the multi-indicator approach to German real estate price analysis are indeed distinguishable along all these dimensions. Hence, it comes as no surprise that numerical differences exist. In the following section, the quantitative extent of these differences is explored by looking at the annual percentage changes of RPPI including houses and apartments, MDPI and CPPI including office and retail. Furthermore, it is evaluated whether the price indices give, at least, consistent signals in terms of direction of change and change in momentum. In Section 3.2, the differences between the bulwiengesa and vdp RPPIs are studied in detail, as the availability of regional data for both of them make it possible to disentangle source and weighting effects.

[7] In practice, private data providers maintain transaction databases containing object-specific information about prices, rents and yields. In many cases, the information set is not complete. Hence, it is supplemented by estimates for the missing piece using the mathematical relationship between the triple of pricing information.

3.1 A view on RPPI, MDPI and CPPI including breakdowns

Measurement uncertainty is evaluated on the basis of the real estate price indices presented in Section 2. Results are reported both for the headline measures, i.e. RPPI-DE, MDPI-DE and CPPI-DE, and for the breakdowns by object type, namely apartments, houses as well as office and retail. In addition, measurement uncertainty is also investigated for RPPI-C7, MDPI-C7 and CPPI-C7 including the breakdowns.

3.1.1 Measures of bias and dispersion

Measurement uncertainty exhibits several dimensions. Metrics which capture quantitative aspects of measurement uncertainty are the mean deviation MD, the mean absolute deviation MAD and the (root of) mean squared deviation $(R)MSD$, for instance. For computational reasons, it is necessary to define a reference. The bulwiengesa indices are chosen for that because, for every object type and city level as well as combinations among these categories, it is able to find or to compile a respective bulwiengesa index.

In particular, the quantitative dimensions of measurement uncertainty are analysed on the basis of metrics calculated as follows:

$$MD = \frac{1}{T(I-1)} \sum_{t=1}^{T} \sum_{i=1}^{I-1} \left(\hat{p}_t^i - \hat{p}_t^I \right)$$

$$MAD = \frac{1}{T(I-1)} \sum_{t=1}^{T} \sum_{i=1}^{I-1} \left| \hat{p}_t^i - \hat{p}_t^I \right|$$

$$MSD = \frac{1}{T(I-1)} \sum_{t=1}^{T} \sum_{i=1}^{I-1} \left(\hat{p}_t^i - \hat{p}_t^I \right)^2 \; and \;\; RMSD = \sqrt{MSD}$$

where $\hat{p}_a^i$ is the percentage price change in period t, $t = 1, \dots, T$, measured by the index of provider i, $i = 1, \dots, I$, with the reference index from bulwiengesa always being sorted at the last position, i.e. $i = I$.[8]

If $MD \neq 0$, the price indices of the providers under review are subject to trends of different strength. While positive and negative deviations cancel out in MD, MAD and $(R)MSD$ are metrics treating both positive and negative deviations as detrimental. $(R)MSD$ is calculated in addition to MAD not only because it may provide a somewhat different picture (given that deviations are penalised the stronger the larger they are in absolute value). Rather, the quadratic structure of MSD enables an easier mathematical handling and leads to a more intuitive interpretation when it comes to decompositions (as done in Section 3.3).

[8] The numbers of available indices vary from one object type to another.

Table 3 Measures of bias and dispersion in German real estate price indices

in percentage points

metric	residential real estate	*of which*		multi-family dwellings	commercial real estate	*of which*	
		houses	apartments			office	retail
	A. Germany as a whole						
mean deviation	-0.7	0.0	-1.8	-4.0	-2.9	-3.0	-4.1
mean absolute deviation	1.3	1.4	2.1	4.0	2.9	3.5	4.1
root mean squared deviation	1.6	1.8	2.5	4.7	3.4	4.4	4.3
memo items:							
mean	3.5	2.6	5.0	8.1	5.1	6.0	4.8
standard deviation	3.1	2.6	3.8	4.8	2.7	5.3	2.0
	B. seven largest German cities						
mean deviation	-0.7	0.7	-0.9	-1.5	-1.2	-1.7	-0.4
mean absolute deviation	1.4	1.5	1.6	2.1	2.4	2.1	3.3
root mean squared deviation	1.8	2.1	2.1	2.4	2.8	2.7	4.5
memo items:							
mean	6.3	4.3	6.9	9.2	8.0	8.1	7.9
standard deviation	3.5	2.4	3.9	4.8	5.0	9.4	4.3

Time period: 2007-2017. Number of data providers considered: Four for houses and apartments as a whole, three for houses and apartments separatly and two for multifamiliy dwellings as well as for commercial property and for seven largest cities.

Table 3 provides the MD, MAD and $RMSD$ for the percentage changes in RPPI and CPPI including breakdowns as well as MDPI in the period from 2007 through 2017. The MD results for Germany as a whole (see Panel A) show that the trends of the price indices of different providers are not identical. This is generally true of both RPPI-DE and CPPI-DE, though more substantial biases are observed for CPPI-DE than for RPPI-DE. The worse performance for CPPI-DE may be explained to some extent by the fact that the vdp indices include the rural parts of Germany and non-prime buildings, likely being characterised by comparatively moderate price dynamics in recent years, whereas the bulwiengesa indices are based on information for 127 towns and the prime segment only. The coverage mismatch is shared by the MDPI-DE. Hence, it comes as no surprise that the price trend for multi-family dwellings reported by bulwiengesa significantly exceeds that of vdp.

The MD reported for RPPI-DE are relatively close to zero. This result masks that, for houses, the indices even exhibit the same price trend while, for apartments, differences are marked, albeit clearly less significant than for CPPI-DE and MDPI-DE. Against the backdrop that all RPPI really represent Germany as a whole, the good performance supports the view that coverage mismatch is a crucial factor behind deviating price trends. Further evidence can be found by a look at the MD which are reported for indices capturing price trends in the seven largest German cities (see Panel B). As RPPI-C7 does not suffer from a spatial coverage mismatch and CPPI-C7 only to the extent that data for Cologne are missing in JLL indices, the figures are as similarly close to zero as the MD of the RPPI-DE. For commercial property

in largest German cities, this means that, despite heterogeneity with regard to prime/non-prime segments still remaining, it is possible to extract a rather unique price trend from available indicators.

Bad performance with regard to MD carries over to MAD and $RMSD$.[9] Indeed, CPPI-DE including its components and MDPI-DE show a higher MAD than RPPI-DE including its components as a consequence of coverage mismatch. This pattern is also observed in a comparison with the spatially more homogenous RPPI-C7, MDPI-C7, and CPPI-C7. A homogenous spatial basis pays off significantly as the MAD is consistently less than half the standard deviation of price changes whereas the MAD tends to surpass the standard deviation otherwise. An exception is the office price index for Germany as a whole whose MAD is large in absolute terms but small in comparison with the substantial volatility of office price changes.

With 1.3 percentage points, the smallest MAD is observed for RPPI-DE. The MAD of house prices (also referring to Germany as a whole) and the MAD of residential property in the seven largest German cities are only marginally higher. With about 4 percentage points, the worst MAD is observed in the case of MDPI-DE and retail prices for Germany as a whole.

It is worth mentioning that the MAD of RPPI-DE and RPPI-C7 tend to be lower than those of its respective components, suggesting that aggregation across object types helps in terms of reducing measurement uncertainty. In the case of commercial real estate, this is true of CPPI-DE. By contrast, the measurement of CPPI-C7 suffers from strong uncertainty regarding retail prices while the price changes for office space deviate only to a small extent.

3.1.2 Frequencies of uniform and mixed signals

Even if the price indices of different providers deviate from each other in terms of percentage change, analysts might appreciate to observe that they share a uniform qualitative pattern in terms of the direction of change or, perhaps more interestingly in the time period under review,[10] an increasing or declining price trend. In the case of a uniform pattern, the relative frequencies are further differentiated between positive and non-positive, i.e. $\hat{p}_t > 0$ and $\hat{p}_t \leq 0$ in the case of direction of change and $\hat{p}_t - \hat{p}_{t-1} > 0$ and $\hat{p}_t - \hat{p}_{t-1} \leq 0$ in the case of gaining or losing momentum.

RPPI-DE and CPPI-DE of different data providers send uniform signals regarding the direction of change in more than 80 per cent (Panel A in Table 4). In the overwhelming number of cases, price increases are reported. In the period under review, the available indices leave

[9] MAD is consistently lower than $RMSD$ for all price indices under review, implying that the measurement deviations which exceed one percentage point are more frequent than those falling short of this threshold. For more volatile price indices such as multi-family dwellings and office, the distance between MAD and $RMSD$ is larger. However, the results derived on the basis of MAD hold true for $RMSD$. In what follows, the focus is therefore on MAD.

[10] The sample under review covers – to the overwhelming part – a period of markedly rising real estate prices. Hence, analysts might not be very much impressed by a set of indicators proven to uniformly signal a positive direction of change. They might rather want to assess the quality of the multi-indicator approach by looking at its capability to send uniform signals regarding the change in momentum.

no doubt about the trend in office prices and, with regard to house prices and the MDPI-DE, there is only one mixed signal. However, the price indices of different providers share the direction of change in about 75 per cent in the case of apartment prices and only marginally above 50 per cent in the case of retail prices.

RPPI-DE and CPPI-DE of different providers report a uniform change in momentum in 60 per cent of the years under review. The percentage is even higher in the case of MDPI-DE, office and retail prices. The latter case is characterised by a notable coincidence of bad performance concerning the direction of change and very good performance concerning the change in momentum. Apartments are the only object type for which available indices send mixed signals in the majority of years.

Table 4 Frequencies of uniform and mixed signals

as a percentage

event	residential real estate	*of which*		multi-family dwellings	commercial real estate	*of which*	
		houses	apartments			office	retail
	A. Germany as a whole						
uniform direction of change	82	91	73	91	82	100	55
of which							
increase	73	73	73	91	82	82	55
decrease	9	18	0	0	0	18	0
mixed direction of change	18	9	27	9	18	0	45
uniform change in momentum	60	60	40	70	60	70	90
of which							
acceleration	40	40	30	60	50	40	60
deceleration	20	20	10	10	10	30	30
mixed change in momentum	40	40	60	30	40	30	10
	B. seven largest German cities						
uniform direction of change	100	91	100	100	82	100	100
of which							
increase	100	91	100	100	82	82	100
decrease	0	0	0	0	0	18	0
mixed direction of change	0	9	0	0	18	0	0
uniform change in momentum	50	50	40	60	70	80	30
of which							
acceleration	50	40	40	50	60	50	30
deceleration	0	10	0	10	10	30	0
mixed change in momentum	50	50	60	40	30	20	70

Time period: 2007-2017. Number of data providers considered: Four for houses and apartments as a whole, three for houses and apartments separately and two for multi family dwellings as well as for commercial property

In general, the information taken from I indices can be viewed as valuable if the relative frequency that all indices send the same signal exceeds the threshold $2^{-(I-1)}$. This would be the probability of a uniform signal if the signal of each index were determined by independent coin flips. In a setup with two indices, the threshold is 50 per cent, and it is 25 per cent in a setup with three indices. In this perspective, even the 40 per cent likelihood of a uniform signal reported for the change in momentum in the set of three apartment price indices can be regarded as valuable information, too.

Considering the direction-of-change signals provided by the available indices for prices of real estate in the seven largest German cities, a virtually perfect pattern emerges in the period under review (Panel B in Table 4). Concerning RPPI-C7 and metropolitan apartment prices, there is no disagreement at all, and the house price indices send a mixed signal only in one year. The MDPI-C7 of the two providers share the direction of change in each year under review. With regard to CPPI, the direction of change does not match in two years. At first glance, this seems struggling given the complete consistence in both office and retail prices. However, recall the fact that the weighting scheme differs strongly between bulwiengesa and vdp in CPPI-C7. This creates mixed signals in the two years where the office price declined while retail prices tended upward.

As regards change in momentum, available RPPI-C7s do not provide valuable information because the frequency that the two indices send a uniform signal does not exceed 50 percent. This is true of both the aggregate over object types and the breakdown. By contrast, the CPPI-C7 is informative in this sense as well as the office price indices but not the retail price indices.

3.2 Measurement uncertainty across regional RPPI breakdown

In the regional dimension, the RPPI is disaggregated along four settlement structures, with the seven largest German cities – of course, all of them belonging to large district-free towns and cities. Against the backdrop that this regional breakdown provides information to analysts, it is worth evaluating the measurement uncertainty of the indices.

Table 5 shows that the MD of RPPI-SSs tend to be more negative than the MD of RPPI-DE and RPPI-C7. The only exception is the price index of urban districts whose MD is very close to that of the RPPI-DE. This sub-aggregate outperforms the RPPI-DE and the RPPI-C7 in terms of MAD.[11] The other RPPI-SSs are somewhat more dispersed than the RPPI-DE and the RPPI-C7. However, their MAD are located in a range between 50 and 60 per cent of the standard deviation, which turns out to be a rather good performance overall.

[11] This statement holds for $RMSD$ too. As in Section 3.1.2, the conclusions drawn on the basis of $RMSD$ do not differ from those drawn on the basis of MAD. Hence, the description in this paragraph is limited to the latter metric.

Table 5 Measures of bias and dispersion in regional RPPIs

in percentage points

metric	total	*of which*				seven largest German cities
		large district-free towns and cities	urban districts	more densely populated rural areas	sparsely populated rural districts	
mean deviation	-0.8	-1.9	-0.7	-1.4	-1.6	-0.8
mean absolute deviation	1.6	1.9	1.1	1.6	1.7	1.5
root mean squared deviation	1.8	2.2	1.4	2.1	2.1	1.9
memo items:						
mean	3.9	5.7	3.1	3.1	3.0	6.8
standard deviation	3.0	3.1	3.0	3.1	3.0	3.4

Time period: 2009-2017. Two data providers are considered.

Table 6 reveals that the very good performance of RPPI-DE regarding uniform direction-of-change signals holds true for RPPI-SSs, too. With respect to the change in momentum, the RPPI-SSs of the two providers send uniform signals in the clear majority of periods. However, the relative frequencies vary in the relative wide range between 90 per cent and just above 50 per cent, with no systematic pattern emerging along the urban-rural dimension.

Table 6 Frequencies of uniform and mixed signals of regional RPPIs

as a percentage

metric	total	*of which*				seven largest German cities
		large district-free towns and cities	urban districts	more densely populated rural areas	sparsely populated rural districts	
uniform direction of change	90	90	100	90	90	100
of which						
increase	80	90	80	70	70	100
decrease	10	0	20	20	20	0
mixed direction of change	10	10	0	10	10	0
uniform change in momentum	89	89	67	56	78	56
of which						
acceleration	67	78	56	56	67	56
deceleration	22	11	11	0	11	0
mixed change in momentum	11	11	33	44	22	44

Time period: 2009-2017. Two data providers are considered.

3.3 Disentangling data source and weighting effects in RPPI

Thanks to the (internal) availability of price data for the 401 administrative districts from bulwiengesa and vdp, it is possible to shed light on the reasons for measurement deviations. In particular, the deviations in the percentage changes of the price indices are decomposed into the effects of different source data and weighting schemes. The basic idea is to use the weighting scheme the Deutsche Bundesbank applies to the bulwiengesa data for the aggregation of vdp district level data, too. This calculation results in hybrid aggregate price indices which are sourced by vdp but weighted like bulwiengesa – in some sense being positioned halfway between the (pure) bulwiengesa and vdp indices. In formal terms, this means:

$$\hat{p}_t^{vdp} - \hat{p}_t^{bul} = \left(\hat{p}_t^{vdp} - \hat{p}_t^{hyb}\right) + \left(\hat{p}_t^{hyb} - \hat{p}_t^{bul}\right)$$

where $\hat{p}_t^{hyb}$ is the percentage change of the hybrid price index. The first term measures the part of the deviation which stems from the weighting scheme because $\hat{p}_t^{vdp}$ and $\hat{p}_t^{hyb}$ are both based on vdp district level data but aggregated with different weighting schemes. The second term measures the contribution of the source because $\hat{p}_t^{bul}$ and $\hat{p}_t^{hyb}$ differ in this respect while sharing the weighting scheme.

From this decomposition, it follows that the MD between vdp and bulwiengesa is made up by a source component and a weighting component and the MSD by the same components plus a covariance term.

$$MD^{vpd,bul} = \frac{1}{T}\sum_{t=1}^{T}\left(\hat{p}_t^{vdp} - \hat{p}_t^{hyb}\right) + \frac{1}{T}\sum_{t=1}^{T}\left(\hat{p}_t^{hyb} - \hat{p}_t^{bul}\right)$$

$$MSD^{vdp,bul} = \frac{1}{T}\sum_{t=1}^{T}\left(\hat{p}_t^{vpd} - \hat{p}_t^{hyb}\right)^2 + \frac{1}{T}\sum_{t=1}^{T}\left(\hat{p}_t^{hyb} - \hat{p}_t^{bul}\right)^2 + \frac{2}{T}\sum_{t=1}^{T}\left(\hat{p}_t^{vdp} - \hat{p}_t^{hyb}\right)\left(\hat{p}_t^{hyb} - \hat{p}_t^{bul}\right)$$

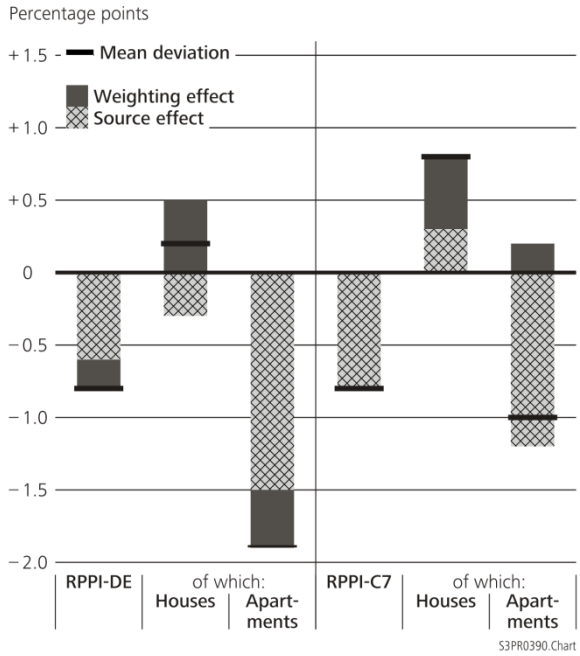
Figure 1 illustrates the results of this decomposition for the RPPI-DE and the RPPI-C7 as well as in the breakdown along the four settlement structures. As regards the decomposition of MD, two observations are shared by all aggregates under consideration. First, weighting and source effects are equally signed. Thus, there is no reason to hope that the two effects might, at least partially, compensate each other to the benefit of a bias reduction. Second, the weighting effect turns out to be smaller than the source effect in absolute value, with the partitions ranging from almost one-to-one through one-to-four.[12]

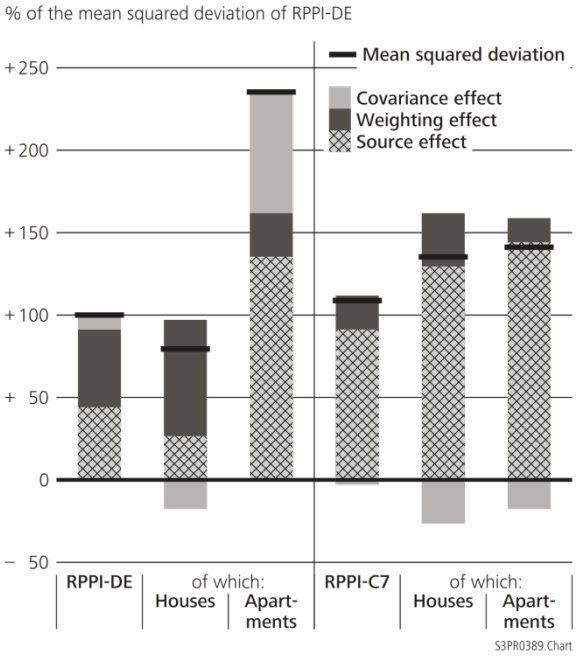
The decompositions of MSD generally mirror the results found for MD. In most instances, the source effect outweighs the weighting effect by a substantial margin. The only exception is RPPI-DE where deviating weighting schemes contribute roughly as much to dispersion as

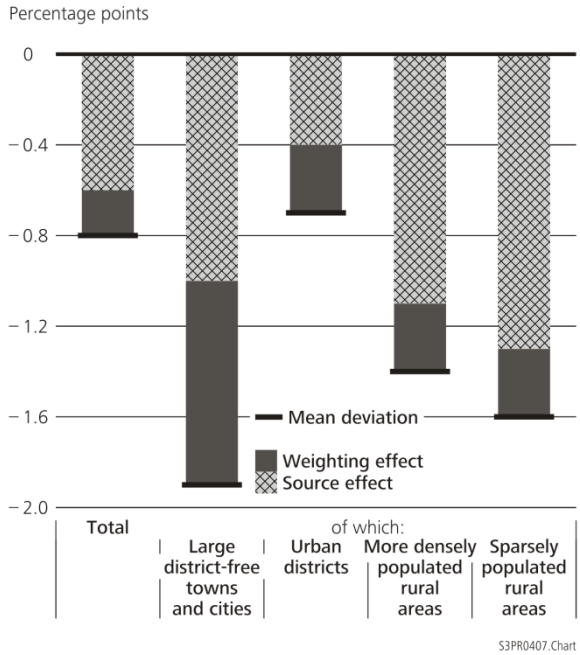
[12] The quantitative statement concerning the relative size of the effects does not apply to the RPPI-C7 given that the weighting effect is virtually zero.

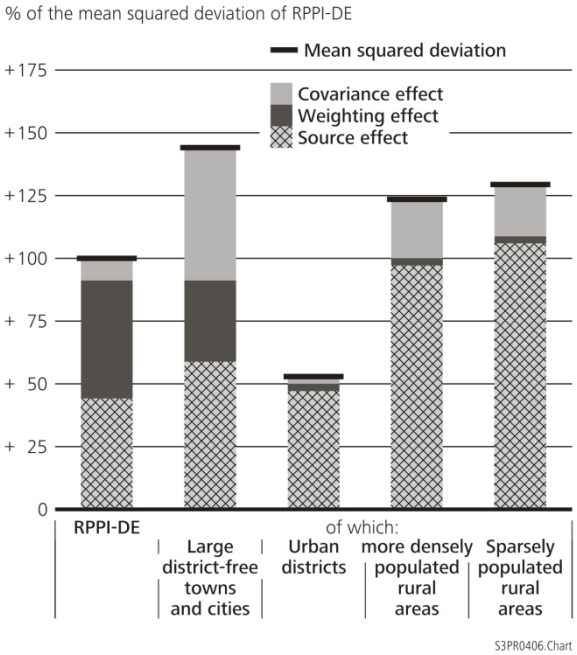
different data sources. The covariance effect is positive for all regional aggregates but one, reflecting that the two components of index diversion tend to move in the same rather than opposite directions.

Figure 1 Disentangling weighting and source effects in RPPIs including breakdowns









The small MD between the percentage changes in total-economy house prices provided by bulwiengesa and vdp is due, first, to a comparatively small source effect and, second, an op-

positely directed weighting effect. By contrast, the apartment price changes which bulwiengesa and vdp report for Germany as a whole deviate quite strongly from each other in terms of data sources, with heterogenous weighting schemes producing an add-on. The prices changes reported by the two providers for apartments located in the seven largest German cities do not suffer from a similarly detrimental source effect, and the weighting effect is small and compensating.

The decomposition of MSD reveals that houses are the object type which mitigate the source effect on RPPI-DE. It amounts to one-fifth of the source effect contributing to the dispersion of apartment price changes. However, the weighting effect is comparatively large and makes up the most substantial part of the MSD reported for total-economy house prices. As regards the object-type breakdown of RPPI-C7, the pattern is unique in the sense that dispersion is caused by different data sources to the overwhelming part.

4 Volatility and correlation of real estate prices

In this section, the volatility of real estate prices changes and the correlation among each other and with key macroeconomic variables are analysed. This is done with a view on measurement uncertainty as the similarity or dissimilarity of the results, which are calculated with bulwiengesa and vdp indices, are compared.

The empirical volatilities and correlations are based on annual time series of percentage changes starting in 2004 and ending in 2017. The price indices considered are RPPI-DE including houses and apartments, MDPI-DE, and CPPI-DE including office and retail.[13] While the vdp indices really capture Germany as a whole, the bulwiengesa indices refer to 127 towns and cities. This ensures that the intra-provider correlations along object types are not disturbed by a change in regional coverage given that the city group is the broadest coverage shared by bulwiengesa RPPI, CPPI and MDPI. To evaluate the association of real estate prices with macroeconomic and demographic trends, the correlations of price index changes with economic growth (measured by the percentage change of the GDP), employment growth and population growth are considered.

Table 7 indicates that vdp indices are less volatile than bulwiengesa indices for all object types except the merger of office and retail. This is likely due to the fact that office prices which exhibit highest volatility across object types are given a substantially higher weight in vdp CPPI than in bulwiengesa CPPI. The volatility difference is particularly apparent in RPPI and MDPI where the vdp indices account to only between 50 per cent and 60 per cent of the bulwiengesa counterparts. A reason for that might be seen in the steeper trends of the bul-

[13] In the remainder of this section, RPPI, MDPI and CPPI are not supplemented by a "-DE" for the sake of readability.

wiengesa indices provided that one accepts the assumption that the amplitude of fluctuations increases in the steepness of the trend.

Table 7 Volatility and correlation of real estate prices

	residential real estate	*of which* houses	*of which* apartments	multi-family dwellings	commercial real estate	*of which* office	*of which* retail
	A. bulwiengesa AG						
I. standard deviation	**4.07**	**2.98**	**4.67**	**6.09**	**3.69**	**6.64**	**2.94**
memo item: mean	2.28	1.02	2.93	4.55	2.69	2.86	2.58
II. correlation[1] with…							
residential real estate	**1**						
of which houses	**0.90**	**1**					
	(0.24)						
appartments	**0.93**	**0.88**	**1**				
	(0.24)	(0.24)					
multi-family dwellings	**0.87**	**0.86**	**0.87**	**1**			
	(0.29)	(0.27)	(0.30)				
commercial real estate	**0.76**	**0.74**	**0.75**	**0.82**	**1**		
	(0.30)	(0.27)	(0.31)	(0.37)			
of which office	**0.76**	**0.71**	**0.76**	**0.81**	**0.90**	**1**	
	(0.31)	(0.30)	(0.31)	(0.38)	(0.37)		
retail	**0.73**	**0.73**	**0.72**	**0.80**	**0.92**	**0.84**	**1**
	(0.28)	(0.26)	(0.29)	(0.35)	(0.36)	(0.36)	
GDP	**0.12**	**0.06**	**0.14**	**0.06**	**0.25**	**0.35**	**0.18**
	(0.08)	(0.07)	(0.11)	(0.08)	(0.05)	(0.13)	(0.06)
employment	**0.37**	**0.24**	**0.40**	**0.41**	**0.45**	**0.56**	**0.36**
	(0.27)	(0.27)	(0.26)	(0.26)	(0.27)	(0.22)	(0.29)
population	**0.81**	**0.83**	**0.78**	**0.75**	**0.66**	**0.70**	**0.61**
	(0.26)	(0.28)	(0.25)	(0.26)	(0.27)	(0.31)	(0.24)
	B. vdpResearch						
I. standard deviation	**2.31**	**2.34**	**2.77**	**3.55**	**4.79**	**6.86**	**2.63**
memo item: mean	1.06	0.99	1.33	1.61	0.64	1.63	-1.02
II. correlation[1] with…							
residential real estate	**1**						
of which houses	**0.92**	**1**					
	(0.33)						
appartments	**0.78**	**0.69**	**1**				
	(0.30)	(0.30)					
multi-family dwellings	**0.71**	**0.68**	**0.68**	**1**			
	(0.30)	(0.31)	(0.25)				
commercial real estate	**0.31**	**0.30**	**0.27**	**0.43**	**1**		
	(0.25)	(0.25)	(0.17)	(0.15)			
of which office	**0.20**	**0.20**	**0.17**	**0.31**	**0.91**	**1**	
	(0.20)	(0.22)	(0.14)	(0.09)	(0.42)		
retail	**0.55**	**0.51**	**0.57**	**0.71**	**0.66**	**0.54**	**1**
	(0.26)	(0.27)	(0.22)	(0.25)	(0.19)	(0.21)	
GDP	**0.04**	**0.10**	**-0.15**	**0.16**	**0.46**	**0.47**	**0.23**
	(0.12)	(0.11)	(0.14)	(0.08)	(0.20)	(0.25)	(0.05)
employment	**0.16**	**0.19**	**0.03**	**0.44**	**0.32**	**0.33**	**0.11**
	(0.29)	(0.26)	(0.31)	(0.22)	(0.14)	(0.12)	(0.26)
population	**0.81**	**0.79**	**0.73**	**0.86**	**0.41**	**0.29**	**0.69**
	(0.33)	(0.33)	(0.27)	(0.29)	(0.16)	(0.13)	(0.27)

Property prices are deflated by the German Consumer Price Index.

1) Heteroskedasticity and autocorrelation consistent standard errors in parentheses.

A substantive difference between the indices of the two providers is that the correlations between bulwiengesa RPPI, MDPI and CPPI are consistently high (i.e. not smaller than 0.8). In the case of vdp, however, the degree of commonality slopes down from RPPI through MDPI to CPPI. Namely, while the correlation between RPPI and MDPI is 0.7, it is 0.4 between MDPI and CPPI and even 0.3 between RPPI and CPPI. At least two reasons can be found to explain this result. First, real estate prices across all object types might indeed co-move more strongly in the 127 towns and cities than in Germany as a whole. Second, it might play a role that bulwiengesa indices reflect expert appraisals which might, consciously or unconsciously, be tilt towards a common trend impacting all segments of real estate markets.[14]

This conjecture is confirmed by the observation that vdp indices show a more pronounced, and economically more comprehensible, correlation pattern with macroeconomic variables. While both vdp and bulwiengesa RPPI and MDPI correlate strongly with population (about 0.8) and weakly with GDP and employment, only from vdp data it can be inferred that correlation of CPPI is closer with variables representing economic activity than those reflecting demographics. By contrast, the bulwiengesa CPPI is still more correlated with population than with GDP or employment.

To conclude, vdp indices provide more distinctive correlation patterns than bulwiengesa indices. As these differences also make sense in economic terms (while the fallacies of bulwiengesa indices might be explainable by the very nature of appraisal data), the results from Table 7, Panel B, are taken as reference to formulate corollaries of volatility and correlation analysis to the amalgamation of object type-specific price indices which is addressed in Section 5.2.

5 Providing real estate prices statistics for various uses

Real estate price indices are an integral part of a comprehensive statistical information system of real estate markets which is needed for various tasks and purposes. Macroeconomists are interested in studying, for instance, the impact of real estate developments on business cycles, the role of real estate in fixed capital formation and wealth accumulation and its repercussions on consumption and investment via wealth effects and collateralisation. Due to the high degree of spatial heterogeneity, real estate market analysis also focuses on regional developments. In addition, real estate markets are an important field of structural and social policy. Government measures range from setting framework conditions (e.g. urban development and planning, granting building permissions) to direct market interference such as subsidising construction and regulations of prices and rents. The credit market

[14] Appraisal smoothing is a phenomenon which is well known among real estate market analysts. Quan and Quigley (1991) figured out that appraisal smoothing is consistent with an optimal updating strategy appraisers might pursue to effectively extract definite price signals from the universe of opaque market information.

channel through which real estate market developments impact the banking sector is of particular importance for financial stability analyses. Under specific circumstances, the risk taking by banks and other credit institutions may become systemic for the financial system as a whole because of deep interlinkages within the sector and beyond.

The various applications require real estate market information be processed and prepared in specific formats. Aggregation and weighting issues are prominently discussed among users. The price indices under consideration in the previous sections feature standard characteristics such as regional disaggregation and the split in RPPI, CPPI and MDPI. This data structure deems workable for many applications while, for some, it is restrictive. In what follows, this structure is not taken for granted. The exposition is being organised from general to specific. In Section 5.1, the issue of aggregation and disaggregation is discussed along the landmarks of economic informative value and statistical feasibility. This helps advocate that the multi-purpose nature of real estate price analysis deserves a multi-indicator approach. The challenge of classifying multi-family dwellings exemplifies the need for purpose-specific configurations of real estate price indices (Section 5.2). In Section 5.3, the main suggestions for a split between residential and commercial real estate are surveyed. In Section 5.4, the alternative definitions are implemented using bulwiengesa data for 127 German towns and cities. For the residential side, this allows to study similarities and differences of the competing concepts.

5.1 Economic informative value and statistical feasibility

Each property is unique. This is due to location before all. Uniqueness induces the highest degree of heterogeneity and makes the compilation of real estate prices a very complex matter. Nonetheless, users demand for indices capturing price trends which are representative to specific classes of real estate. These classes are defined by balancing the economic informative value and statistical feasibility. The economic informative value refers to the purpose of the analysis (e.g. macroeconomic diagnosis, regional market studies, financial stability analysis). Statistical feasibility depends on data issues such as the granularity of price information and the availability of coherent weighting schemes. For statistical feasibility, methodological aspect may also play a role as, for instance, quality adjustment may become a critical factor in index compilation.

For some economic applications, it is desirable to identify as detailed price developments as possible. In another context (e.g. international price comparisons), the availability of an all-inclusive headline measure would be most welcome. Both ends of the aggregation spectrum pose statistical problems. Too much disaggregation risks at inducing uncertainty in index compilation because the number of observations is not sufficiently large for a proper statistical handling. An aggregation across all types of real estate might harm the statistical quality

of price indices because coverage is unevenly distributed across object types and a coherent weighting scheme is missing.

Practice has steered a middle course. Regional disaggregation currently draws on meaningful and not too detailed groupings. For residential real estate in Germany, providers tend to converge to city groups and a classification of administrative districts along settlement structures. For commercial real estate, however, a comparable standard is still missing. Aggregation across object types generally refers to the economic use of the structure. This criterion is not sufficient in two cases. When structures have a multi-purpose character (e.g. retail space on the ground floor and apartments in the stories above), additional criteria are needed. This issue seems manageable and is thus of secondary order in the current debate among producers and users of real estate prices.

Of more practical relevance is the classification of multi-family dwellings. The subsequent section addresses this challenge in detail, thereby not only referencing specific handling in policy setups but also referring to the implications of the volatility and correlation analysis laid down in Section 4.

5.2 The classification of multi-family dwellings

Multi-family dwellings make up a substantial share in housing stock in Germany. In these structures and the housing units rented out in single-family and two-family houses, almost half of the German population live as tenants.[15] According to the Census of Buildings and Housing 2011, about three-fifths of multi-family dwellings are owned by private households and a quarter by private enterprises including cooperatives.[16] As social housing (i.e. state-owned blocks with housing units rented out at rates not in line with market conditions) is of minor importance and rents are relatively less regulated, the transaction market for multi-family dwellings in Germany may be regarded as sufficiently broad and undistorted to ensure competitive pricing.

Thus, it is important to deal with multi-family dwellings when it comes to analyse the German real estate market. Owing to its magnitude, it is of relevance for both the residential and the commercial segment, with – broadly speaking – residential denoting any property providing shelter for the user and commercial denoting any property generating yields for the owner. The assignment of multi-family dwellings is currently subject to a lively debate, and the abovementioned landmarks play a role in that. Starting with informative value, one could argue that, as a general rule, multi-family dwellings shall be considered as residential property

[15] The rental housing market in Europe is very heterogenic across countries. For example, the share of the rental housing market in Romania is very low. Only 3 % of the population live in rented accommodation. Eurostat, http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_lvho02&lang=en

[16] A major reason for the comparatively high share of multi-family dwellings owned by private households is that rented accommodation has been considered an asset for wealth accumulation. In Germany, self-employed persons were often not covered by public or private retirement schemes. See ECB (2009), Box 3, for details.

if the user's perspective is taken and as commercial property if the owner's perspective is taken (e.g. Deutsche Bundesbank, 2013).

When following this rule, two pitfalls should be taken into account, however. First, an investor may be indifferent between buying, for instance, a multi-family dwelling and some apartments in separate dwellings. From the owner's perspective, commercial property should not only comprise multi-family dwellings but also buy-to-let houses and apartments which requires split these object types according to owner-occupancy.[17] This is statistically feasible only if object types are weighted on the basis of stocks (given that information about the ownership of real estate is available). In the case of a transaction weighting, however, the assignment of houses and apartments remains inconclusive as transactions are frequently associated with a switch from owner-occupied to buy-to-let and vice versa.[18]

Second, an investor generally makes decisions on the basis of expected returns. This entails risk considerations. The risk of a real estate investment depends, among other things, on expected price fluctuations and possible diversification potential in the asset portfolio. Hence, object types should be combined if their price developments are similar in terms of volatility, co-movement and correlation with macroeconomic variables such as GDP, employment and population.[19] Recall from Section 4 that MDPI is more volatile than RPPI and its components. It is also more volatile than CPPI. While office prices show a higher volatility than MDPI, retail prices are rather stable. The correlation of MDPI is stronger with RPPI than with CPPI. And considering the correlation of price indices with key macroeconomic variables, more similarities can be found between MDPI and RPPI than between MDPI and CPPI. On the basis of this thought experiment and empirical evidence, one could make the case for assigning multi-family dwellings to the residential segment even taking an owner's perspective.

5.3 Definitions of residential and commercial real estate in use

Current practice in Europe operates with several definitions for residential and commercial real estate. The definitions are generally intended to be applicable in each and every real estate statistic, e.g. stocks, credits, transactions, prices, building permits and starts. In this paper, however, the focus is on those aspects of the definitions which are relevant for price statistics.

[17] This corresponds to the broadest definition of commercial property considered in Eurostat (2017), Section 4.2.1.

[18] It would be principally possible to solve the assignment problem if it were determined whether the seller's use or the buyer's (intended) use decides. Apart from the fact that this is actually an arbitrary choice, lacking or misleading information turns out to prevent such a decision rule from being operational.

[19] In empirical capital asset pricing models, the correlation between the return on individual assets and performance measures of a market portfolio is considered.

In the Capital Requirements Regulation (CRR), which is applied in banking supervision as well as in the AnaCredit project,[20] residential property is explicitly defined as a "residence which is occupied by the owner or the lessee of the residence" (EU, 2013, Article 4, para. 75). This means that houses and apartments – irrespective of being owner-occupied or rented out – as well as multi-family dwellings are regarded as residential real estate. The definition thus implements the user's perspective. The CRR does not offer an explicit definition for commercial real estate. The European Banking Authority suggests taking the complement, i.e. all properties which are not classified as residential shall be taken as commercial (EBA, 2014).

The European Systemic Risk Board (ESRB) published a recommendation on closing real estate data gaps which includes an explicit definition of commercial property, namely to be "any income-producing immovable property, excluding social housing, property held by end-users and buy-to-let housing" (ESRB, 2016, Annex V). This definition implements the owner's perspective with the exception that buy-to-let housing, i.e. *any* form of dwelling which is "owned by private households, with the primary aim of being let to tenants." (ESRB, 2016, Annex V), is regarded as residential. Splitting income-generating dwellings along the legal status of the owner is reasoned by the macroprudential argument that buy-to-let activity undertaken by private households – proxying "part-time, non-professional landlords with a small portfolio" (Dierick et al., 2017, p. 9) – resembles more owner-occupied housing than commercial real estate investments in terms of risk monitoring and potential macroprudential policy action. The ESRB Recommendation is explicit about taking the complement of commercial as residential (ESRB, 2016, Section 2).

In Eurostat (2017), a building-blocks approach to real estate classification is suggested. The basic idea of this is to enable flexible groupings and thus best serve the users' analytical interests. In general, various splits between residential and commercial are conceivable. However, statistical feasibility may restrict the number of options. Nonetheless, delineations according to the user's or the owner's perspective are implementable.

Table 8 highlights in a simplified illustration that the definitions found in the CRR and the ESRB recommendation are not compatible in the sense that they result in an equivalent residential-commercial split. The ESRB recommendation does not implement the owner's perspective in its pure form. This is represented by the broadest definition of commercial property exemplified in Eurostat (2017).

[20] AnaCredit stands for "Analytical credit data standards" and denotes an ESCB project which is aimed at collecting granular credit and credit risk data.

Table 8 Residential-commercial split according to several definitions in use

definition	houses and apartments			multi-family dwellings		office	retail
	owned by enterprises	owned by private households		owned by private households	owned by enterprises		
		rented out	owner-occupied				
Credit Requirements Regulation (CRR)	**residential**					**commercial**	
ESRB recommendation on closing real estate data gaps	**commercial**	**residential**			**commercial**		
Broadest definition of commercial real estate in Eurostat (2017)	**commercial**		**residential**	**commercial**			

This illustration does not cover the complete stock of real estate properties. For instance, social housing as well as industrial and logistics properties are excluded. The illustration also abstracts from buildings under construction.

5.4 Price indices for different definitions of residential property

[…]

6 Conclusion

The main conclusions drawn from the evaluation of measurement deviations between German real estate price indices are the following. First, the uncertainty entailed in the usage of a variety of indicators might be regarded as limited if the price indices do not suffer from a coverage mismatch. This refers not only to the frequency of providing uniform signals as regards the direction of change and the change in momentum but also quantitative measures such as mean deviation and mean absolute deviation. As coverage mismatch is less relevant for RPPIs than for CPPIs and MDPIs, the multi-indicator approach works better for tracing out developments in residential than in commercial property markets. Focusing on metropolitan office, retail and multi-family dwellings markets (i.e. property in the seven largest German cities) helps improve measurement quality and reduce the mismatch problem with favourable effects on the informative value of a multi-indicator approach. Second, measurement deviations in RPPIs are shown to be due more to differences in source data than in weighting schemes. Third, transaction-based real estate price indices provide a more distinctive volatility and correlation pattern than their appraisal-based counterparts, giving reasons for a preferential use of the former. Fourth, the deviations between the price indices of residential property following different definitions in use […].

The empirical results may support the view that, in the current stadium of imperfect data provision, a multi-indicator approach is a robust strategy to distil the relevant information for real

estate analysis with a contained risk of creating confusion. Thanks to the ongoing efforts to reduce information gaps in official real estate price statistics,[21] the multi-indicator approach is expected to be pushed back as regards the data source dimension. Nonetheless, a complete disappearance turns out to be unrealistic many years ahead because this would require statistical offices get access to the universe of information about real estate market activities and be able to process it in a way that results in a set of definite price indices applicable for the complete spectrum of policy uses. For RPPIs, such a scenario might be achievable if the legal, institutional, and technical prerequisites for a complete, immediate and efficient usage of administered data for the purpose of official statistics are accomplished, as this would equip official statisticians with the by far richest information base in this segment.[22] For CPPIs and MDPIs, a multi-indicator approach may persist because, even under optimal conditions regarding the transfer of administered data, official price indices will not surely achieve a dominating status over any private product. Impediments are the enormous heterogeneity of office and retail properties as well as multi-family dwellings, the comparative small number of transactions in this segment and its incomplete administrative recording (due to share deals, for instance) as well as the absence of census-like information for the derivation of a weighting scheme.

[21] For instance, residential and commercial real estate statistics are addressed in recommendations 17 and 18 of the second phase of the G-20 Data Gaps Initiative.

[22] In Germany, each property sale is documented by a notary and registered by tax authorities. In addition, the stock of residential property is completely recorded by a decennial census.

References

Deutsche Bundesbank (2003), Price indicators for the housing market, Monthly Report, September 2003, 45-58.

Deutsche Bundesbank (2013), Commercial property prices in Germany: conceptual considerations and statistical status quo, Monthly Report, May 2013, 53-55.

Dierick, Frank, Emmanuel Point, Wanda Cornacchia and Mara Pirovano (2017), Closing real estate gaps for financial stability monitoring and macroprudential policy in the EU, IFC-National Bank of Belgium Workshop on "Data needs and Statistics compilation for macroprudential analysis", Brussels, 18-19 May 2017.

European Banking Authority (2014), Single Rulebook Q&A, Question ID 2014_1214, https://eba.europa.eu/single-rule-book-qa/-/qna/view/publicId/2014_1214.

European Central Bank (2009), Housing finance in the euro area, Occasional Paper 101, March 2009.

European Union (2013), Regulation (EU) No 575/2013 of the European Parliament and of the Council on prudential requirements for credit institutions and investment firms and amending Regulation (EU) No 648/2012 ("Capital Requirements Regulation", CRR).

European Systemic Risk Board (2016), Recommendation of the European Systemic Risk Board on closing real estate data gaps (ESRB/2016/14), 31 October 2016 ("ESRB Recommendation").

Eurostat (2013), Handbook on Residential Property Prices (RPPIs), 2013 edition, Luxembourg: Publication Service Office of the European Union.

Eurostat (2017), Commercial property price indicators: sources, methods and issues, 2017 edition, Luxembourg: Publication Service of the European Union.

Hoffmann, Johannes and Andreas Lorenz (2006), Real estate price indices in Germany: past, present and future, paper prepared for the OECD-IMF Workshop on real estate price indexes, Paris, 6-7 November 2006.

Leifer, Hans-Albert (2004), Preisindikatoren für Wohnimmobilien in Deutschland, Allgemeines Statistisches Archiv 88, 435-450.

National Statistician (2010), Review of House Price Statistics, Government Statistical Service, December 2010.

Quan, Daniel C. and John M. Quigley (1991), Price formation and the appraisal function in real estate markets, Journal of Real Estate Finance and Economics 4, 127-146.

Silver, Mick (2011), House price indices: Does measurement matter? World Economics 12, 3, 69-86.

Silver, Mick (2014), The degree and impact of differences in house price index measurement, Journal of Economic and Social Measurement 39, 305-328, 2014.